APR 4 1927

Motorship

Registered in U. S. Patent Office and abroad

Four U. S. Army Hopper Dredges like this

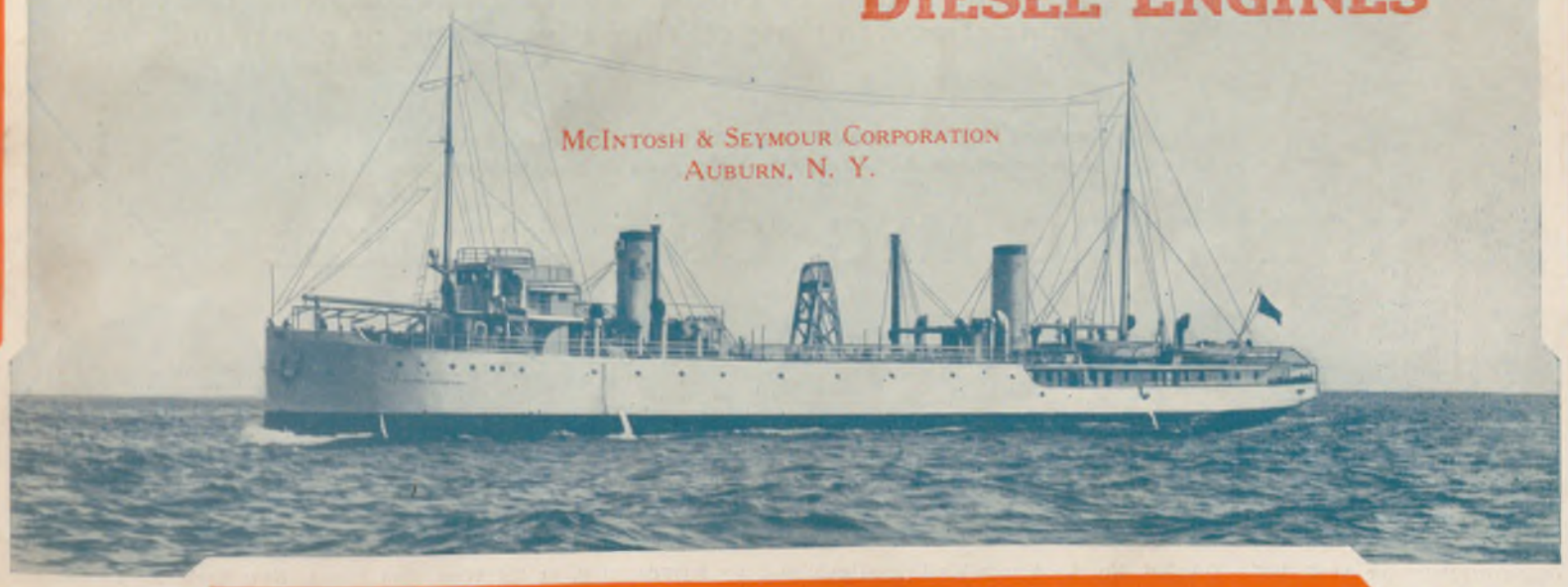
"A. MacKenzie" "W. L. Marshall" "Dan C. Kingman" "William T. Rossell"

—all Diesel-electric-equipped throughout

WITH Diesel-electric capacity greater than in any other hopper dredges built and electricity utilized even for heating and cooking, these four Army Dredges of 1200 cu. ft. capacity each, are a decided engineering advance over steam-operated types.

Three 700-kw. main and two 150-kw. auxiliary generators in each of these vessels are served respectively by three 1000-b. hp. and two 225-b. hp.

McINTOSH & SEYMOUR DIESEL ENGINES



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Volume XII — April, 1927 — *Number 4*

Diesel-Electric Propulsion for Big Transatlantic Liner Powers?

Proposed Conversion of Agamemnon and Mount Vernon Opens Up Possibility of New Fields and New Developments in Diesel Engineering Suggesting an All-Electric Ship

THERE is one problem which at the present time is exercising the minds of Diesel engine builders and naval architects, and that is the question of powering the high-powered ship. For powers up to 20,000 or 25,000 hp. a Diesel engine is a sure proposition. Its reliability is unquestionable, its economy is proven and the satisfaction it gives is universal, but it is in terms of powers above this in large ships and for powers below this in small fast ships that the progressive designer is now thinking. In a word the progressive man is beginning to lay his plans for an attack in that field, which at the present time is largely entirely within the domain of the steam turbine and water tube boiler.

Shipping Board to Spend $12,000,000

The thought which really inspires this discussion is the recent announcement that the Shipping Board is considering spending a sum of $6,000,000 on reconditioning each of the ex-German transatlantic "flyers" AGAMEMNON and MOUNT VERNON. The announcement is also made that if this work is to be carried out it will entail the complete gutting of the ships, their entire reconstruction and the fitting of turbine propelling machinery with water tube boilers similar to that installed on the new Matson liner MALOLO. MOTORSHIP naturally is a strong advocate for the Dieselisation of such ships because it realizes that even though the initial expenditure on some form of Diesel propelling machinery would be inevitably greater than that for which steam machinery could be purchased, the economy of operating results would more than offset the initial additional expenditure. The problem, however, is one which cannot and should not be attacked bald-headed. The power involved is a high one and the ships at present have an exceptionally fine design of tandem reciprocating engines developing a total of 45,000 s.hp. on four shafts. These engines, incidentally, were produced at a time when the steam reciprocating engine had reached its zenith for efficiency and the steam turbine was beginning to make its presence felt on the North Atlantic and other trade lanes as something new in marine propulsion.

A 42,000 hp. Proposition

The present total of 45,000 s.hp. is a big power, slightly bigger than anything which has yet been projected for Diesel engines. We understand, however, that a power considerably less than that is intended when the two ships are converted. Cosulich Line visions 42,000 s.hp. with a tandem arrangement of two single-acting engines on each of four shafts and proposes furthermore to adopt a novel arrangement whereby decks over the engine spaces will be completely decked in. This is an arrangement which has hitherto not been adopted for any layout that we know of and yet it is one of the obvious advantages accruing from Diesel drive. The Vulcan Werke of Germany has a proposal for 42,000 s.hp. also on four shafts, with 16 short, small, high-speed, trunk piston engines coupled in fours per shaft through the medium of oil clutches or couplings, through which all maneuvering can be carried out from one central control. The sixteen engines are uni-directional in rotation and require very little attention while maneuvering since the whole of this function is carried out by a centralized control operating all pumps to all oil clutches. This is a very rough and brief idea but it shows the principles and has much to recommend it, especially the advantage that although the total horsepower is split up into a large number of prime movers and spread around over a larger deck area than would be necessary with large high power units, it does not absorb headroom, and suggests a flexibility of power concentration which may be absent from the big engine layout.

The Diesel-Electric Thought

It is, then, but a short step from this thought to the thought that electric drive is going to have a great deal of say in big marine power plant layouts of the future, and it is a subject to which leading manufacturers of oil engines in America are devoting considerable thought. Engines of this type can be manufactured reasonably and cheaply in this country. Electrical power plant is available readily and American marine electrical engineers have a better understanding of ship power plants than their opposite numbers in any other country in the world. Electric drive has been born and brought up in American ships and this country has approached the question with characteristic freshness of outlook and absence of prejudice. Let us connect the two thoughts. The AGAMEMNON and MOUNT VERNON may be reconditioned for service. They will not be converted in the accepted sense of the word. They will be gutted and rebuilt.

High Powers Available

We feel that right at this moment Diesel power plant is available for arrangement in ships of this type and especially any power plant which is capable of combination with electric drive. Theoretically, there is no limit to the number of small generating units which can be placed in a ship provided there is sufficient space to accommodate them. It is obvious, of course, that there should be as small a number as possible but there is no reason that the number selected should be confined even to one deck. Diesel-electric drive for such ships cuts out at once the auxiliary enginerocm, in itself no small item. It means that you can vary your output absolutely to suit your requirements, and with the aid of storage battery arrangements can make your layout even more economical to operate.....These are but thoughts, which deserve careful consideration. They open up vistas of future fields. They show possibilities of development.

As time goes on, big ships will inevitably become more and more electric. Shipping men will definitely have to shape their ideas and accustom their minds to the progress of "Diesel-electricity." The electrician, for his part, is taking up maritime problems as something new.

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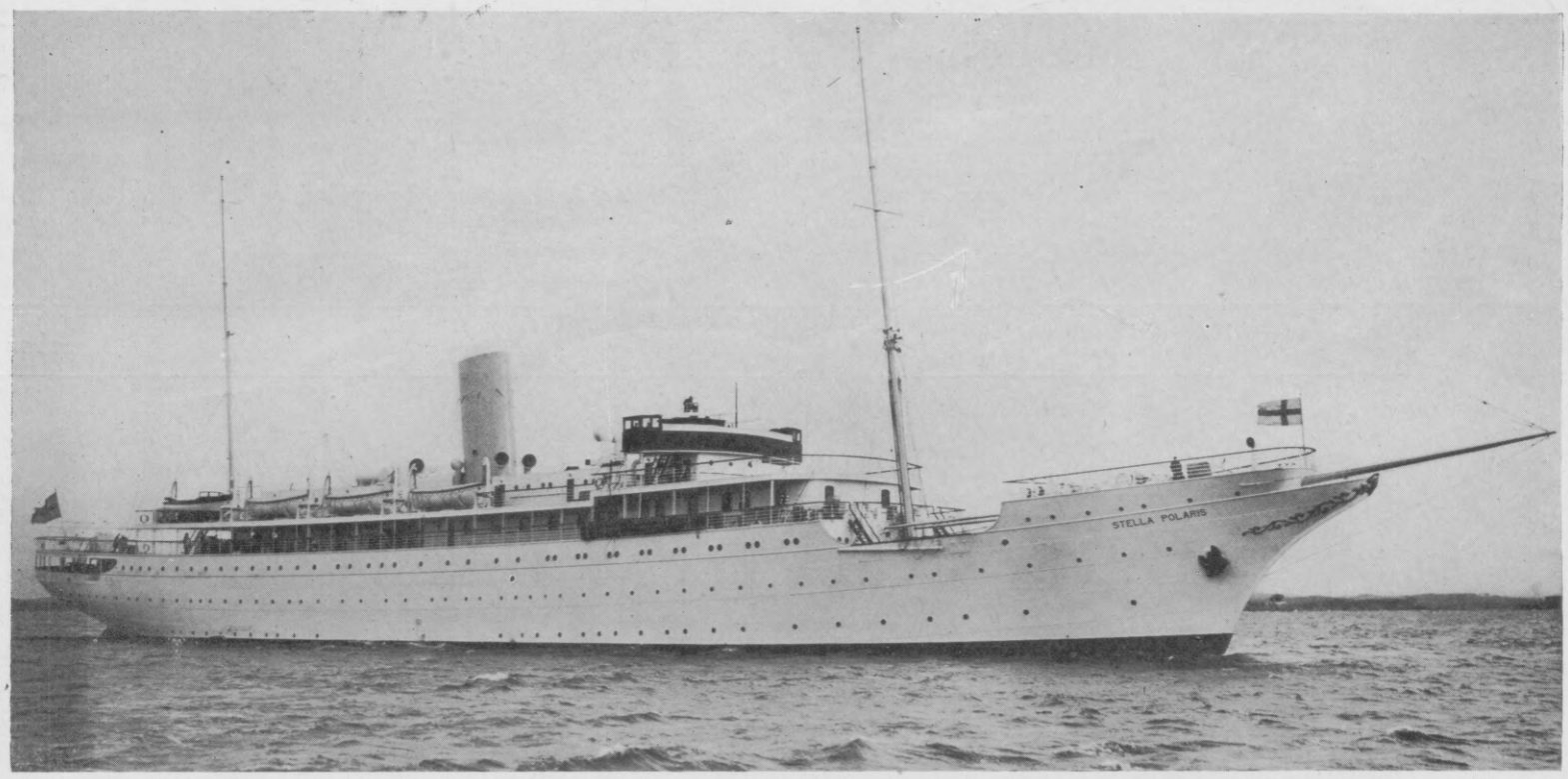
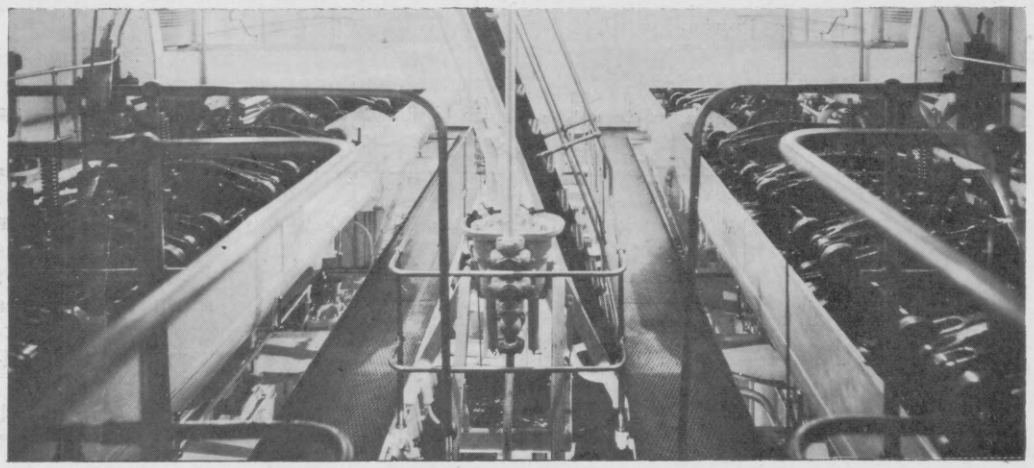
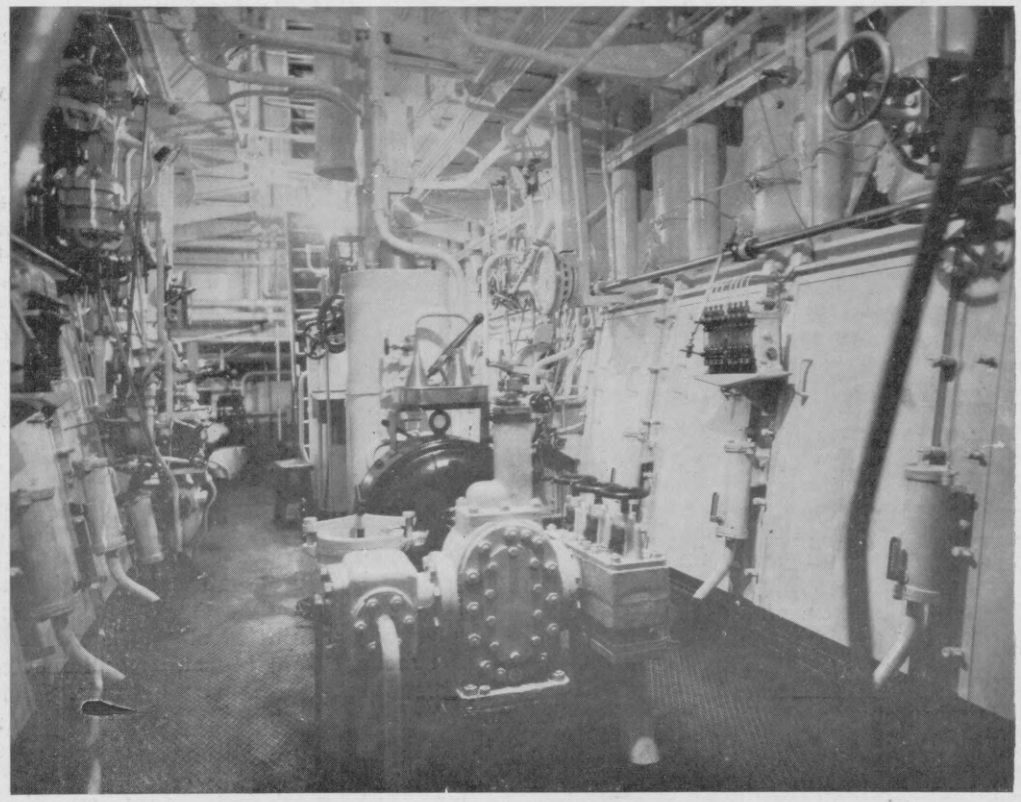


Big Cruising Ship Is Diesel Powered for Economy

Motoryacht Stella Polaris of 5200 hp., specially designed for ocean cruise work





Engine room of Motoryacht Stella Polaris shows clean, silent running machinery, giving maximum economy to the owners and comfort to guests

Well appointed lounge

BERGENSKE SS. CO., Oslo, Norway, has probably had as much experience as anyone in the cruising business. In the winter they cruise in the Mediterranean; in the summer they cruise to the Norweigan fjords. The ships employed for the work hitherto have been converted vessels. Coal difficulties in Europe and the dirt, heat, and general uncomfortable impression left in fastidious passengers' minds with steamers has, no doubt, been instrumental in leading the company to ask Götaverken, Gothenburg, Sweden, to build them an up-to-date cruise yacht propelled by Diesels. Ms. STELLA POLARIS is 428 ft. long —she has been described in detail in MOTORSHIP—and has over 5000 hp. given by her B. & W. Diesels. In American waters we use ships of the same size and power for cruising to Florida and in the West Indies, but we prefer to use uneconomical steam plants in them. Such powers are moderate and well within the range of products of domestic engine builders.

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Sixth Converted Shipping Board Motorship Completes Her Sea Trials

Steady Operation Features Sea Tests of Busch-Sulzer-Engined Sawokla Attended by Two Shipping Board Commissioners and U. S. Navy Engineering Head

CRITICS of the Shipping Board's conversion program are admitting that it is working out much better than was anticipated. Considerable enthusiasm was expressed by about one hundred guests, observers and crew on the sea trials of the sixth converted vessel to be completed under the program. These took place on March 12th, in Hampton Roads.

Ms. SAWOKLA, as the new ship is called, has been fitted by the Newport News Shipbuilding & Dry Dock Co. with the first of four 3000 b.hp. Busch-Sulzer Diesels constructed under the first section of the $25,000,000 program. These functioned perfectly and except for a slight delay to adjust the steering-gear mechanism the 8 hour endurance trials were carried through without a hitch, and although the vessel was in light condition there was not the slightest semblance of vibration. After the tests she proceeded to Philadelphia to load cargo for her maiden voyage to South America, on the completion of which she will be allocated to Roosevelt Lines Australian service.

Our observations have shown us that the successful trials and passing into service of these converted ships one after another, coupled with the splendid performances they are all making to date, is stimulating the interest of the entire Shipping Board as well as that of private owners the world over. On SAWOKLA'S trials Commissioners Jefferson Myers and Philip Teller were present, as also was Admiral R. E. Griffin, Chief-Engineer of the U. S. Navy, and Capt. J. Q. Walton, Instructor for U. S. Coast Guard. Captain R. D. Gatewood, who has been responsible for the engineering and ultimate success of the conversion program was in charge of the trials for the Board.

Three of the converted ships which have been placed in service to date, it will be recalled, have main engines of the single-acting 4-cycle type, and two vessels have been equipped with double-acting 2-cycle engines. All five ships have single-screw installations. The Busch-Sulzer engine in ms. SAWOKLA is of single-acting, 2-cycle type with air injection.

Characteristics of Ms. Sawokla

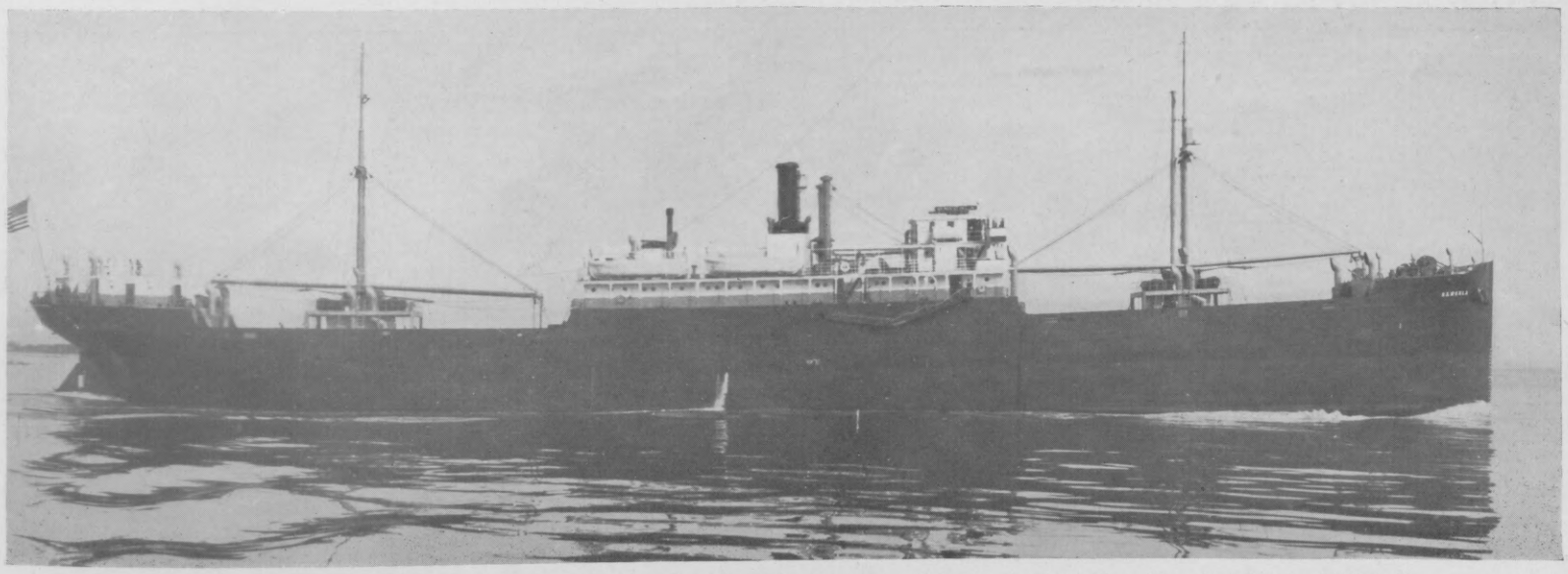
Gross register	5878 tons
Net register	3689 tons
Length overall	416 ft. 0 in.
Length b.p.	402 ft. 0 in.
Beam, molded	54 ft. 0 in.
Depth, molded to main deck	33 ft. 9 in.
Displacement load	13,010 tons
Mean draft at above	26 ft. 10¾ in.
Power—main engine	3000 s.hp.
Service speed (about)	11½ knots
Total deadweight capacity	9125 tons
Fuel oil, double bottom	760 tons
Cargo spaces (bale)	455,660 cu. ft.
Cargo spaces (grain)	448,030 cu. ft.
Deep tanks (liquid)	1053 tons

In view of the splendid showing being made by all boats and engines in service to date, and in view of the comparatively slight differences in dimensions and tonnages of the different ships, it is difficult to make comparisons of merit. In fact, the belief is well justified that no poorly constructed engines are turned out by the leading American Diesel-engine builders today.

The Busch-Sulzer Diesel engine of the SAWOKLA has six working cylinders 30 in. bore by 52 in. stroke and develops 3000 b.hp. at 90 r.p.m. with a piston speed of 780 ft. per min. It drives a 4-bladed, built-up bronze propeller 17 ft. 9 in. diameter by 14 ft. pitch. Exhaust gases are carried out at the small stack amidships characteristic of Shipping Board motorships via Maxim silencers, which incidentally are fitted on the auxiliary engines. While the exhaust itself is quiet, we noticed a little noise from the scavenge air intake on the boat deck near the stack, and we heard the suggestion made that this could well be fitted with an intake silencer which, judging by the existing arrangement, should be quite a simple operation. If this is done the opportunity could be also taken to install an air filter, which probably would act in a partial way as a silencer, as well as protection for the cylinder liners.

The hull of ms. SAWOKLA is practically a duplicate of those of the TAMPA and UNICOI and has her conversion arrangement a duplicate also of that of the two earlier ships. A full account of the TAMPA type arrangement was given in MOTORSHIP for December, 1926, but it may be interesting here to mention that ms. SAWOKLA is of the 3-island type. Built on the Isherwood longitudinal system with double-bottom tanks, she has 6 cargo holds (one of which is a deep tank), 'tween deck cargo spaces and also spaces for cargo in the poop, bridge and forecastle. These spaces give a capacity of 455,660 cu. ft. for bale cargo and 36,845 cu. ft. in the deep tanks port and starboard.

All the double-bottom tanks in which oil may be carried, and also the deep tanks, are fitted with heating coils. In the double-bottom tanks these coils are near the suctions and not of very large capacity, because normally these tanks do not have to be completely pumped out at one operation, the daily service tanks having a combined capacity of only 10 tons. For the deep



Ms. Tampa, sixth converted Shipping Board motorship, is powered by a single-acting 2-cycle Diesel of 2900 hp.

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tanks the conditions are different, shipments of vegetable oils, for instance, having to be discharged by special pumps and usually under the supervision of representatives of the shipper and of the underwriters. Discharge must therefore be expedited, and for this reason the heating coils extend from deck to bilge along the whole outboard sides of the tanks and are laid across the bottom.

For the handling of cargo into, and out of, the hold there are two winch platforms in the forward and after wells respectively and a third winch station on the boat deck to serve No. 3 hold. These winches use as high a hoisting speed as possible for the average lifts and hoist the heavier slings in double purchase. A rope speed of 185 ft. per min. is employed for weights of 4,000 lb. which form the larger part of all bale cargo, but 10,000 lb. can be lifted in single purchase.

All the living quarters are in the bridge structure and poop and are of the highest standard. For crew, as for officers and for 15 passengers, the living spaces are roomy, well lighted, well ventilated, properly protected against cold, thoroughly screened, equipped with fans throughout, with ample lockers, comfortably furnished and brightly finished.

The complement of the ship comprises: the captain, 3 deck officers, radio operator, boatswain, carpenter and 10 seamen on deck; chief engineer, 4 assistants, electrical asst. and 4 motormen and 2 wipers below; steward, 2 cooks, 2 messmen and 3 messboys amidships; a total of 37.

C. Carageorge, chief engineer who will have charge of the Busch-Sulzer installation has the reputation of being a very fine operating engineer. He was chief for 3 years of the Ss. EMPRESS OF INDIA, 2 years chief on the Ss. ADMIRAL SCHLEY, 3 years chief on the turbo-electric driven ship ECLIPSE and four years Superintendent-Engineer for the Steven-Ransom Marine Works of Brooklyn. He has also had considerable experience with Winton Diesel engines, and was assistant inspector for the U. S. Shipping Board at the Busch-Sulzer Diesel engine works.

Cost of the actual conversion work amounted to $660,080 and in addition a sum of $158,800 was spent on special alterations to the superstructure (which was entirely rebuilt) and for hull repairs, occasioned by the ship having been laid up so long, bringing the total cost up to $819,600 as follows:

Conversion Cost

Installation work	$227,150
Main engine, including spares	247,330
Deck machinery, including steering-gear, motors, controls and cable	29,320
Engine-room auxiliaries, incl. engines, generators, pumps, coolers, switchboard, cable	94,000
Equipment and outfit	25,000
Engineering, purchasing, inspection, traveling, freight, extras, trial trip and incidentals	38,000
Total	$660,800
Special alterations	$132,800
Hull repairs	26,000
Grand Total	$819,600

While the cost may seem high, it must always be remembered that on these Shipping Board vessels something more than actual conversion has been carried out—it is a question of entirely rebuilding and turning an obsolete steamer into an up-to-the-minute motorship, which in itself is no mean task.

Capt. Gatewood's remarks at the luncheon held on board during the trials are also illuminating. He pointed out to the two Shipping Board Commissioners present that if 275 of the Government's steamships now in service were converted by the Board to Diesel power, the entire operating loss now made would be completely wiped out and the operations changed to profit by taking only into consideration the total fuel saved. This would be a theoretically ideal state although not impossible of accomplishment. In the meanwhile, Capt. Gatewood made it clear that he is strongly in favor of converting 30 more ships without further delay.

One definite benefit resulting from the conversion of the U. S. S. B. ships is the greatly increased average speeds attained on voyages that have been made. As already noted in MOTORSHIP, ms. TAMPA averaged a speed of 11.8 knots loaded with cotton on her maiden voyage across the Atlantic, while the WEST HONAKER averaged 10.68 knots, and under favorable conditions made as high as 13.16 knots. On her first trip to Australia this ship averaged 12.6 knots from Scotland Light to Cristobal enroute with a full cargo to Australia. The CROWN CITY, another conversion, recently left her shipyard on a maiden voyage around the world. To date reports indicate that she is making an equally noteworthy performance.

The successful operation of these converted ships is important as more than 300 vessels are operated by the government on 25 established routes. These ships covered in the last fiscal year no less than 11,270,341 nautical miles and carried export and import cargoes valued approximately at $725,000,000, which owing to a loss on the operations cost the American taxpayer during 1926, 2.6 cents for every dollar's worth of goods carried. Alleviation if not elimination of this charge is appreciably within sight by wholesale conversions from steam to Diesel power. Such a step would not only help the Diesel engine building industry as a whole, but would further the interests of the American Merchant Marine, since it would then have a supply of modern tonnage with which to meet foreign competition.

All Diesels to Australia

Complete Dieselisation of its Australian service, which together with its Italian service is being operated by the Roosevelt Steamship Company, is being effected by the Shipping Board, which has allocated the TAMPA and UNICOI, to the company. Ms. SAWOKLA will be added shortly, thus completing the replacement of the six steamships employed on the Australian run.

Kermit Roosevelt, president of the Roosevelt Lines is highly gratified over the Shipping Board's action and believes that shippers and the government will both benefit as a result, the former by better service and the latter by reduction in costs.

The Australian service of the Shipping Board now supports the WEST HONAKER, WEST CUSSETA, CROWN CITY, TAMPA and UNICOI. The first two are already in the trade, and the CROWN CITY sailed on her maiden voyage March 10. She will be followed by the UNICOI on April 20 and the TAMPA on May 1.

During the regular seasons the Indian and Australian lines are operated separately, but inasmuch as the Australian wool season will have ended by the time the CROWN CITY, TAMPA and UNICOI reach the Antipodes, these three motorships will be routed home via India.

Another big motor passenger liner in Atlantic service, ms. Alcantara, 22,000 *tons gross and* 20,000 *i.hp., now on her maiden voyage*

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U.S.S.B. Motorship Sawokla, Converted by Newport News Sb. & D.D. Co., Engined by Busch-Sulzer Bros., St. Louis

Item	Name of Unit	No. of Units	Make	Description and Characteristics
	Propelling Equipment			
1	Main engine	1	Busch-Sulzer	2900 b.hp., 2-cycle single acting, 6 cylinders 30 in. x 52 in., 90 r.p.m.
2	Injection air flask	2	National Tube Co.	5 cu. ft. capacity each (one service, one reserve).
3	Maneuvering-air tank	2	N. Y. Sbdg. Corp.	655 cu. ft. each, 6 ft. 4 in. diameter, 20 ft. 8 in. long, working pressure 400 lb. per sq. in.
4	Exhaust line and muffler	1	N. N. Sbdg. & D. D. Co.	30 in. diameter Armco iron built-up pipe lagged with 2½ in. insulation from water cooled manifold on engine to Maxim silencer in stack and 30 in. outlet to atmosphere.
5	Thrust bearing	1	Kingsbury	32 in. diameter.
6	Shaft	1	———	15½ in. diameter thrustshaft, 14¾ in. diameter lineshaft, 16¼ in. diameter tailshaft.
7	Stern tube	1	N. N. Sbdg. & D. D. Co.	Original cast iron stern tube relined with lignum vitae and fitted with Bethlehem-McNab-Vista system of lubrication; no liner on tailshaft in way of stern tube, but short sleeve where exposed to salt water.
8	Propeller	1	Amer. Mang. Bronze	4-bladed, built-up, 17 ft. 9 in. diameter, 14 ft. 0 in. pitch, 79.63 sq. ft. projected area, 89.4 sq. ft. developed area, 247.45 sq. ft. in disc area.
	Auxiliary Power Equipment			
9	Generator and auxiliary compressor set	3	Worthington-Ridgway	75 kw., 240 volt d.c. generator, direct connected with 115 b.hp. 2-cycle single-acting air-injection engine, 3 cylinders 12½ in. x 13¼ in., 265 r.p.m., with 3-stage oversize compressor of capacity of 170 cu. ft. of free air per min. to assist in replenishing main air tanks.
10	Injection air flask	3	National Tube Co.	One to each engine; capacity 2½ cu. ft. each.
11	Starting air tank	—	———	Air taken from main maneuvering-air tanks.
12	Exhaust line and muffler	1	N. N. Sbdg. & D. D. Co.	10 in. diameter Maxim silencer and 10 in. diameter steel pipe, with 2 in. insulation, leading through stack to atmosphere.
13	Port lighting and pilot compressor set	1	Mianus-Diehl-Rix	14 kw., 240 volt d.c. generator, direct connected with 22 b.hp. 2-cycle airless-injection engine, 3 cylinders 5 5/16 in. x 7⅛ in., 550 r.p.m. and direct connected also with Rix air-compressor of capacity of 14½ cu. ft. of free air per min. to 1000 lb. per sq. in. Hand compressor available for starting.
14	Switchboard	1	Walker	4 generator panels, 2 lighting and auxiliary power panels, 2 testing panels, 3 duplex motor starting panels and 5 single motor starting panels.
	Pump Equipment			
15	Salt water cooling and general service pump	2	Nash-G.E.	750 g.p.m. at 35 lb. per sq. in., self-priming centrifugal, 8 in. suction, 6 in. discharge, 30 hp. motor.
16	Fire pump	1	Nash-G.E.	200 g.p.m. at 100 lb. per sq. in., self-priming centrifugal, 4 in. suction, 3 in. discharge, 20 hp. motor.
17	Engine room bilge pump	1	Nash-G.E.	300 g.p.m. at 20 lb. per sq. in., self-priming centrifugal, 5 in. suction, 4 in. discharge, 7½ hp. motor.
18	Sanitary pump	1	Nash-G.E.	70 g.p.m. at 55 lb. per sq. in., centrifugal, 3 in. suction, 2 in. discharge, 7½ hp. motor.
19	Fresh water pump (washing)	1	Nash-G.E.	70 g.p.m. at 55 lb. per sq. in., centrifugal, 3 in. suction, 2 in. discharge, 7½ hp. motor.
20	Fresh water pump (portable)	1	Nash-G.E.	35 g.p.m. at 30 lb. per sq. in., centrifugal, 2 in. suction, 1½ in. discharge, 2½ hp. motor.
21	Lub. oil circulating pump	1	Kinney-G.E.	150 g.p.m. at 35 lb. per sq. in., rotary, 4 in. suction, 4 in. discharge, 7½ hp. motor driving through Falk flexible coupling and reduction gear.
22	Fuel transfer pump	1	Kinney-G.E.	150 g.p.m. at 35 lb. per sq. in., rotary, 4 in. suction, 4 in. discharge, 7½ hp. motor driving through Falk coupling and reduction gear.
23	Lub. oil hand pump	1	Rumsey	Semi-rotary force pump, 1¼ in. suction and discharge.
24	Fuel hand pump	1	Rumsey	Semi-rotary force pump, 1¼ in. suction and discharge.
25	Fire hand pump	2	Douglas	6 in. x 5½ in. double-acting force pump, 2½ in. discharge.
	Fuel Oil Service			
26	Storage tanks—double bottom	5	———	760 tons total capacity, fitted with heating coils near pump suctions.
27	Raw fuel oil tank	1	———	17½ tons capacity; heating coil 17 sq. ft., built in hull.
28	Fuel oil centrifuge	2	De Laval	Type 600, pressure tight, 300 gal. per hr. with fuel at 210 deg. Fahr.
29	Daily service tank	2	———	7⅛ tons capacity each; heating coil 8.5 sq. ft. in each tank, built in hull.
30	Kerosene oil tank	1	N. N. Sbdg. & D. D. Co.	185 gal. capacity; for emergency starting in extremely cold weather.
31	Catch-all tank	1	N. N. Sbdg. & D. D. Co.	150 gal. capacity; for drains from drip pans.
32	Purified fuel oil tank	1	———	16.5 tons capacity to inlet from purifier; heating coal 17 sq. ft., built in hull.
	Lub. Oil Service			
33	Lub. oil sump tank	2	N. N. Sbdg. & D. D. Co.	4300 gal. total capacity; 4.7 sq. ft. surface of heating coil near pump suction in each tank.
34	Lub. oil purifier	1	De Laval	Type 360.
35	Cylinder oil tank	1	N. N. Sbdg. & D. D. Co.	1800 gal. capacity.
36	Compressor oil tank	1	N. N. Sbdg. & D. D. Co.	200 gal. capacity.
37	Save-all tank	1	———	60 gal. capacity; for drains from drip pans.
38	Dirty lub. oil tank	1	N. N. Sbdg. & D. D. Co.	60 gal. capacity; for used oil from auxiliary engines for centrifuging.
	Misc. Oil Service			
39	Kerosene oil tank	2	———	120 gal. total capacity; engine room cleaning oil.
40	Galley range tank	1	N. N. Sbdg. & D. D. Co.	165 gal. capacity, with heating coil; gravity tank above galley.

(*Continued on page* 272)

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U.S.S.B. Motorship Sawokla, Converted by Newport News Sb. & D.D. Co., Engined by Busch-Sulzer Bros.,

(Continued from page 271)

Item	Name of Unit	No. of Units	Make	Description and Characteristics
	Lifting Gear			
41	Traveling crane	1	N. N. Sbdg. & D. D. Co.	Hand operated, with two 4-wheel, 4-ton Yale & Towne combined chain blocks and trolleys, over the main engine.
42	Combined trolley & chain hoist.	3	Wright Mfg. Co.	4-wheel, 2 ton combined chain block and trolley on I-beam over each generator set.
	Machine Shop			
43	Machine tool	3	See next column	Walcott lathe, Canedy Otto drill press and Meyers grinding wheel stand, with line shafting driven by a 7½ hp. G. E. motor.
	Heating Equipment			
44	Heating boiler	1	N. N. Sbdg. & D. D. Co.	Vertical, 4 ft. 0 in. diameter, 11 ft. 8 in. high, 220 sq. ft. heating surface total, working pressure 110 lb. per sq. in., Coen Sunbeam oil burner.
45	Boiler feed pump	1	Worthington	3 in. x 2 in. x 3 in. horizontal duplex.
46	Hot well tank	1	N. N. Sbdg. & D. D. Co.	156 gal. capacity.
47	Vacuum pump	1	Warren	5½ in. x 8 in. x 7 in. horizontal simplex, for steam return lines from oil tank coils.
48	Evaporator	1	Griscom-Russell	25 tons capacity.
49	Drinking water still	1	Jewell	25 gal. capacity.
50	Fresh water heater and tanks	2	Auto. Elect. Heater Co.	One of 3000 watts 100 gal. capacity in hot fresh water tank. One of 1500 watts 15 gal. for shower and basin in crew's washroom.
51	Electric steam radiator	1	Auto. Elect. Heater Co.	1000 watts capacity for carpenter shop.
	Refrigerating Service			
52	Ice machine	1	Shipley	2 tons capacity, direct expansion ammonia compressor, 2 cylinders, 4 in. x 4 in. single-acting, 275 r.p.m., direct connected with 7½ hp. Diehl motor through Clark flexible coupling.
53	Cooling coils	3	Shipley	Meat room 10 deg. F., 687 cu. ft., 353 linear ft. 1¼ in. pipe. Meat room zero deg. F., 732 cu. ft., 593 linear ft. 1¼ in. pipe. Vegetable room 24 deg. Fahr., 490 cu. ft., 224 linear ft. 1¼ in. pipe, all Reading genuine wt. iron pipe.
54	Cork insulation	—	Cork Import Co.	Two layers of blocks, each 3 in. thick, on floor; 8 in. layer granulated round sides and 10 in. layer granulated on top.
	Deck & Hold Equipment			
55	Anchor windlass	1	American-Clay-Westinghouse	Original 2 5/16 in. stud link cable windlass converted. Now operated by motor of 45 hp. at 450 r.p.m. with Westinghouse controller and Cutler-Hammer magnetic brake. Extra gear reduction between motor and cable drum.
56	Warping winch	1	Lidgerwood-Westinghouse	Same design and size as cargo winches, with additional reduction gear to extension shaft of winch heads.
57	Cargo winch	10	Lidgerwood-Westinghouse	Maximum lift 10,000 lb., normal rating 4000 lb. at 185 ft. per min. Five right-hand and five left-hand. Geared to 25 hp. motor, with Westinghouse controller and Cutler-Hammer magnetic brake.
58	Cargo boom	11	———	Ten 5-ton booms. Length 50 ft. at Nos. 1, 2 and 4 hatches, 29 ft. at No. 3 hatch and 39 ft. at No. 5 hatch. One 30-ton steel boom.
59	Steering gear	1	Amer. Eng. Co.-Westinghouse	Original screw steering gear, operated by 25 hp. motor through Cleveland Worm & Gear Co.'s reduction gear unit and Falk flexible coupling. Westinghouse controller regulated by Sperry electric control from bridge.
60	Fire extinguishing system	1	Lux CO_2	Total 72 bottles of 50 lb. capacity each, arranged in 7 banks, with 10 bottles in reserve and one each in lamproom and paintroom. All 7 banks (70 bottles) can be discharged into engine room simultaneously or into cargo compartments separately.
	Navigation Equipment			
61	Magnetic compasses	3	See next column	Hand in wheelhouse; standard compass on top of wheelhouse; Hand at emergency steering station on top of poop house.
62	Gyro compass	1	Sperry	Mark VIII, Model 2. Repeater at gyro-pilot.
63	Gyro-pilot	1	Sperry	2-unit type. Mark IV, Model 3.
64	Rudder indicator	2	Sperry	One in wheelhouse and one at emergency steering station, on top of poop house.
65	Emergency steering	2	Westinghouse & Amer. Eng. Co.	Electric steering stand with non-follow-up control (Westinghouse) on top of poop house. Hand steering at same station.
66	Mechanical telegraph	2	McNab-Chadburn	One in wheelhouse and other on bridge; indicator in engine room.
67	Telephone	6	Henschel	To stations in captain's office, radio room, chief engineer's office, engine room and steering engine room.
68	Speaking tube	3	Cory	To engine room, captain's stateroom, gyro compass room, chief engineer's room, to engine room and top aft deckhouse.
69	Navigation and signal lights	5	———	Sidelights, masthead light and range light with Russell & Stoll tell-tale panel and portable anchor light.
70	Searchlight	1	Sperry	18-in. incandescent type on top of wheelhouse with control in wheelhouse; fitted with refocussing device to permit use as a floodlight.
71	Radio	1	Ind. Wireless	Spark transmitter; Navy type receiver; Crocker-Wheeler generator.
72	Whistle	1	Sperry	8-in. air whistle Tyfon type with attached flashing lamp of 250 watts in Fresnel lens. Working pressure 100 lb. per sq. in., obtained from maneuvering air tanks through Leslie reducing valve.
73	Fire detector	1	Rich	20 detector lines.
74	Submarine signal apparatus	1	Submarine Signal Co.	Receivers in wheelhouse.

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Development of Ms. Sawokla's Main Engine

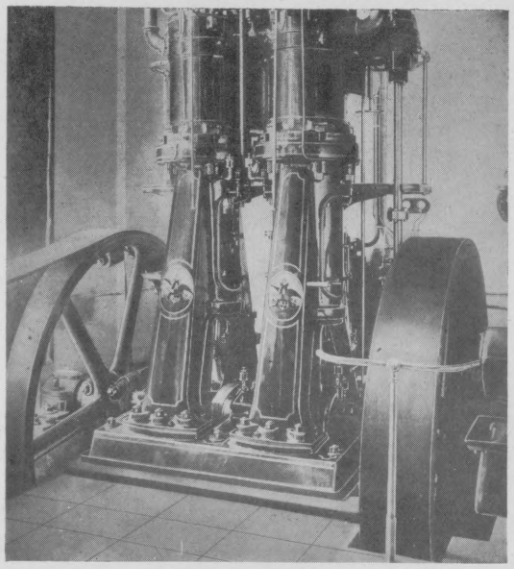
Busch-Sulzer 2-Cycle Diesels of All Powers and Types Have 30 Years of Experience Back of Their Construction

By Edward B. Pollister*

SEA trials of the Shipping Board motorship SAWOKLA which took place last month, call to mind that it is just 30 years ago since Adolphus Busch, founder of the Busch-Sulzer Bros. Diesel Engine Company, after witnessing trials at Augsberg, Germany, of Dr. Rudolph Diesel's first successful engine, purchased Dr. Diesel's existing and future patents for the United States, its possessions, and Canada. He paid in cash, $250,000, which sum was the forerunner of several million dollars he later spent in its development. The 3000 hp. Busch-Sulzer engine driving ms. SAWOKLA'S propeller has fifty times the horsepower of the first engine of 60 hp., completed at St. Louis in 1898.

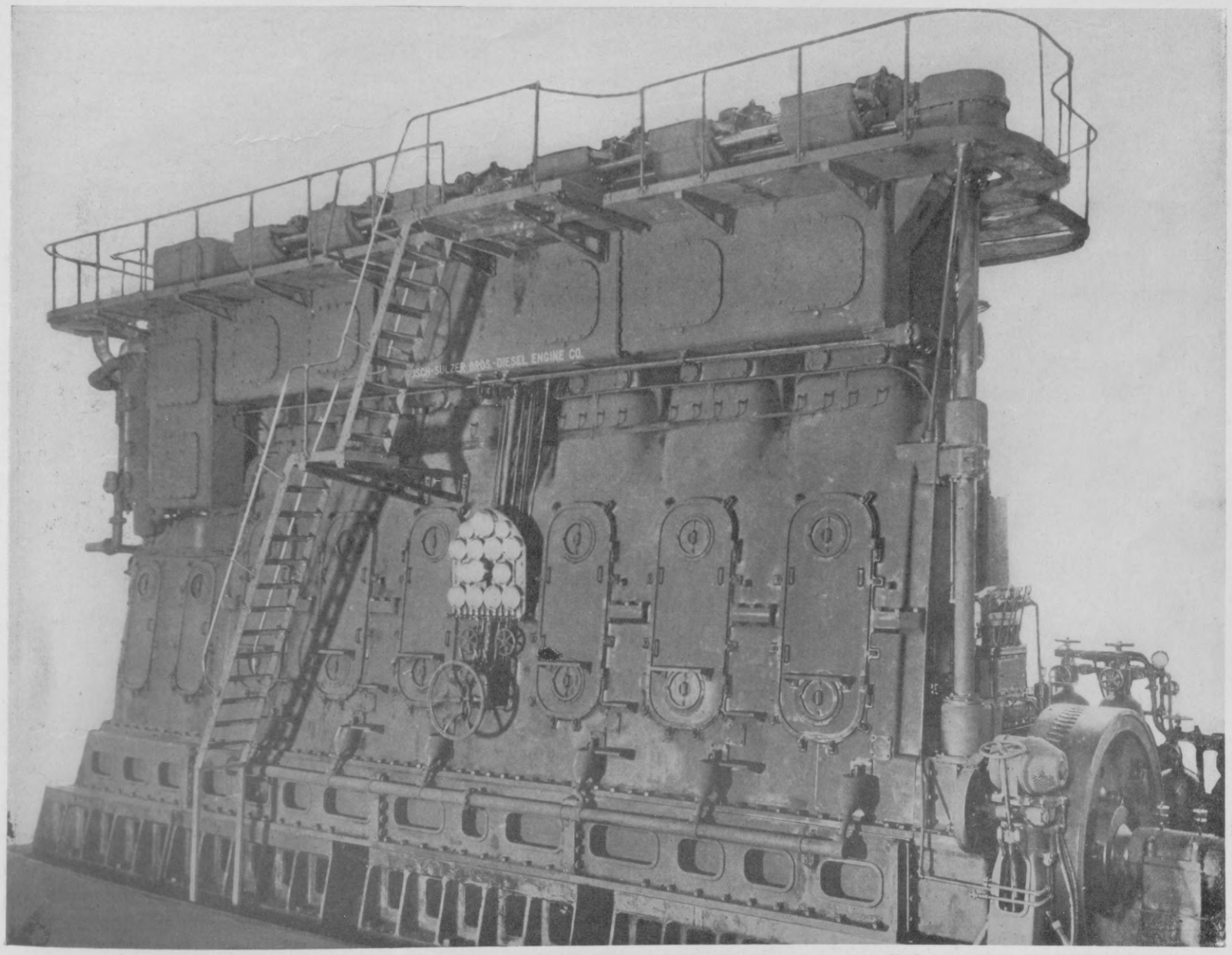
SAWOKLA'S engine is one of six large marine engines totalling 15,000 hp. placed in production early in 1925 at the Busch-Sulzer St. Louis works. This 15,000 hp. shop order called for the development of two different sizes, a twin screw installation of 4-cylinder 30 in. bore x 42 in. stroke engines for the Standard Oil (N. J.) tanker E. T. BEDFORD completed in December, 1925, being followed by four single screw 3,000 hp. engines for the Shipping Board, each having six cylinders 30 in. bore x 52 in. stroke, completed in 1926.

Following closely in all essential features the well established Sulzer marine Diesel, the Busch-Sulzer engine fitted in ms. SAWOKLA presents a striking simplicity, the result of repeated re-designing during the past 10 years. Accordingly it may have less appeal for those seeking something new, when compared with double-acting engines supplied under the Shipping Board conversion program, where entirely new problems of both design and operation were presented, and so courageously attacked.



Pioneer engine built in 1898

*General manager, Busch-Sulzer Bros. Diesel Engine Co.



The main propelling Diesel of the converted Shipping Board Motorship Sawokla, a 6-cylinder Busch-Sulzer unit

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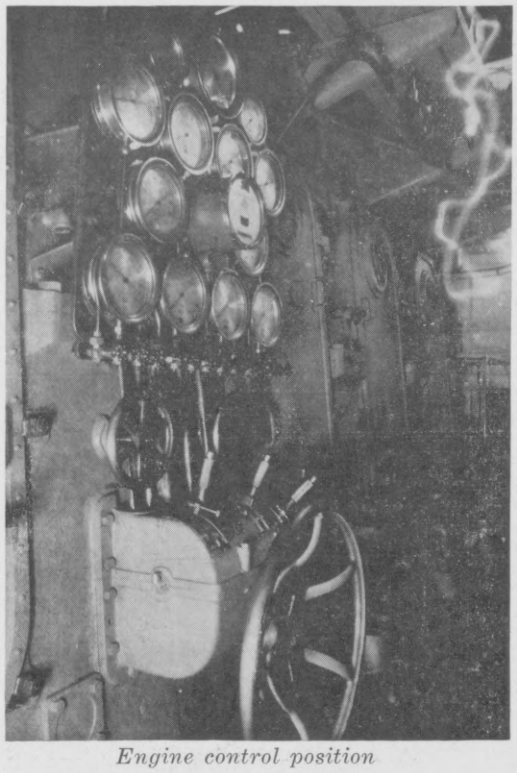
A total of 30 years' experience has, however, contributed much to the production of these comparatively high power but extremely simple engines. This experience embraces early years of the Busch organization alone and later the extensive research and valuable development work of Sulzer Brothers of Winterthur, Switzerland. To find suitable designs and materials to withstand the Diesel combustion chamber temperature of burning fuel, 3,000 deg. Fahr. under cylinder pressures of 500 lb. to 600 lb. per sq. in., (which produce by the way a working load on a 30 in. diameter piston of over 200 tons) requires time. Time is the necessary element to disclose weakness of design or materials under such severe duty; and time is again necessary to test corrective measures.

Busch-Sulzer marine history embraces the supplying of over seventy highly specialized Diesel engines for the propulsion of submarines. This group includes six engines, each developing a maximum of 2,500 b.hp., with weight reduced to about one-third the weight per hp. of the heavy duty, slow speed SAWOKLA type engine. Obviously, this heavy duty engine presented a far less difficult problem of development.



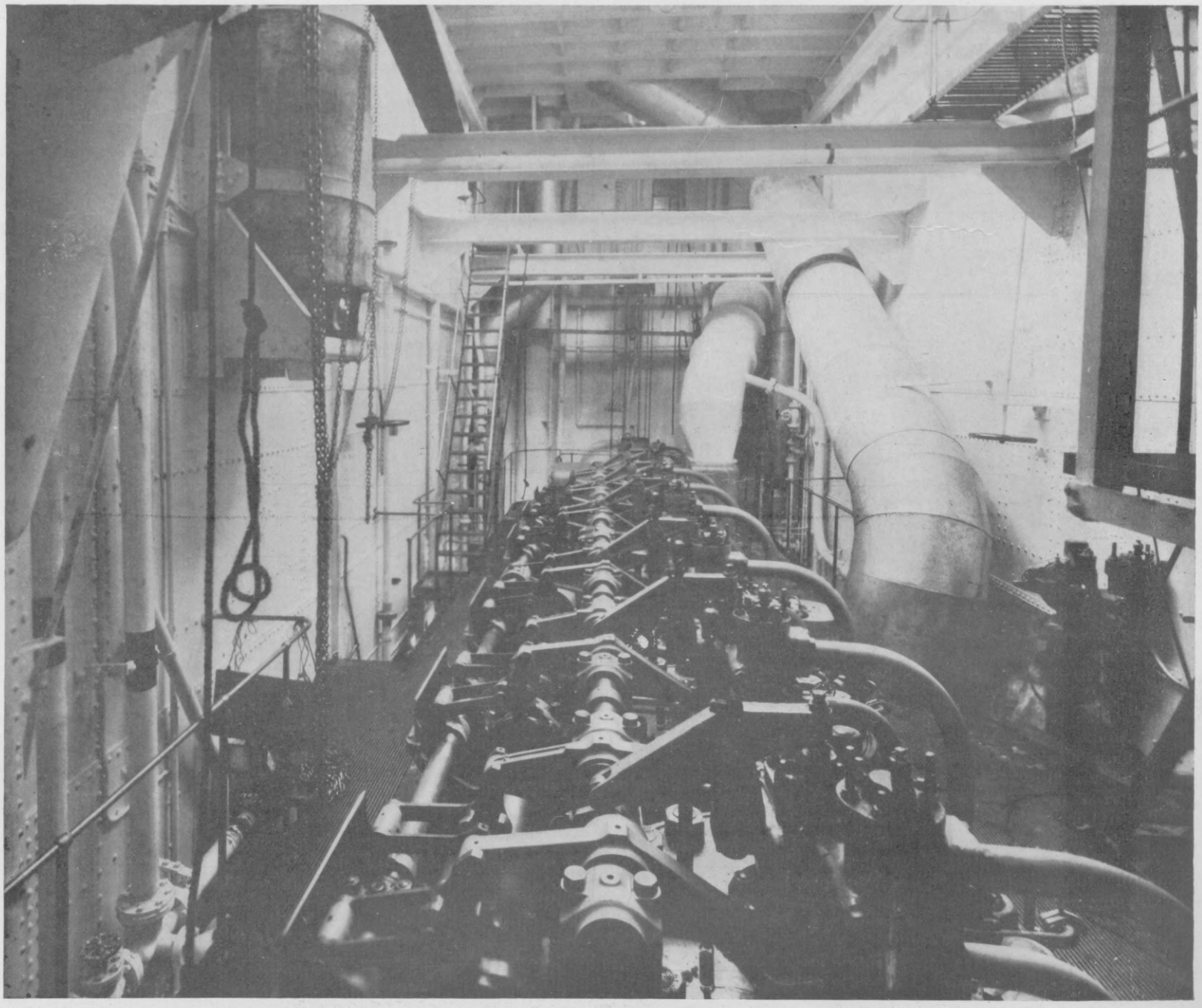
Engine control position

An effort was made, however, to surpass previous similar designs of Busch-Sulzer 2-cycle, single acting Diesels in supplying for the SAWOKLA an engine that would exceed the Shipping Board's specifications and expectations in liberality of rating, ruggedness of design, simplicity of operating features, reduction in weight per hp., low mean indicated pressure, low fuel consumption, and high mechanical efficiency.

A glance at the specifications as made to the Shipping Board covering the four 3,000 hp. Busch-Sulzer Diesels in comparison with the results established by the 30-day non-stop shop test of the first engine, conducted by the Shipping Board, is extremely gratifying to all concerned.

The performance of the engine at overload and overspeed justifies the normal commercial ratings for which the engine was designed, viz. 3400 b.hp. at 95 r.p.m. and 3750 b.hp. at 105 r.p.m. both with mean indicated pressure of under 90 lb. per sq. in.

Working stresses between heads and base are carried by the heavy cast iron frame with ribbing of ample sections, and with small bedplate spread, to keep the forces as



Characteristic Busch-Sulzer features shown in view looking aft along cylinder tops of main engine of U. S. S. B. Motorship Sawokla

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nearly vertical as possible. The upper crank case section is *en bloc* for each set of three working cylinders and combined for the scavenging pump and compressor, contributing stiffness. The lift of the cylinders is hardly noticable, measuring only .0010 in. to .0016 in. at the top of the cylinder head. No expense was spared to carry out the idea of substantial rugged construction. The crankshaft, weighing over 40 tons, is solid forged in two main and one pump sections.

But what most appeals in the SAWOKLA Diesel is the extreme simplicity of the engine, not only to the observer but to the operating engineer. Starting and maneuvering controls are straight leads from the operating station to the air motor, which, with safety interlocks, rotates a lay shaft to cause either starting air or fuel valves to function in proper sequence and for ahead or astern running.

Above the upper platform, the single fuel valve per cylinder is the only moving gear. The compressor valves are without springs. All scavenging valves are self-operating without springs or actuating drives, and for the upper tier of cylinder ports of the well known Sulzer scavenging system, the valves are automatic, being held closed until the exhaust gas pressure falls below the scavenging pressure, a safety feature. The fuel pump is an improved model of many in operation over 20 years.

For marine service with limited room and equipment for anything more than minor overhauling, the small number and small size of the parts that require inspection and adjustment reduce the engineer's work to a minimum. Also, such relatively small parts on so large an engine of single acting 2-cycle type make accessibility an easy accomplishment. Thus we have, small nuts and small wrenches, all working cylinder heads and valve gear top side with a straight vertical lift to remove; a minimum of piping to disturb; and all but a few parts above top grating capable of being manhandled with ease, all of which serve to simplify operation and maintenance.

Since 1915, in the building of many sizes and types of submarine engines where, for submergence requirements, light weight is a controlling factor, Busch-Sulzer has learned how much weight a Diesel needs and where to put it. In our opinion, which is contrary to that of some purchasing agents, who still cling to the price per pound basis for analyzing machinery prices, light weight in a Diesel costs real money. Starting with a normal specified single acting 2-cycle Diesel weight, Busch-Sulzer pared down within limits of both safety and reasonable costs; and, in the SAWOKLA engine, we have approached the weights of double acting engines, on an equal basis of rotative speed, cylinder pressures, thermal and mechanical efficiencies.

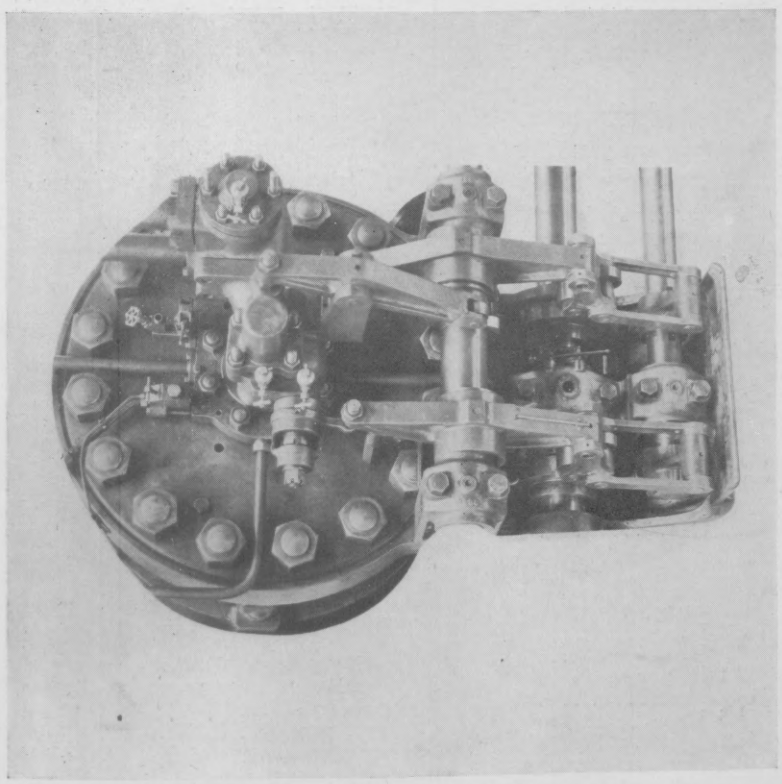
There is no common ground among Diesel manufacturers for rating engines, possibly because the distinctive features of different designs permit variance from any given standards of cylinder pressures, piston and rotative speeds. The Technical Staff of the Emergency Fleet Corporation saw fit to limit the mean indicated pressure of 2-cycle engines to 85 lb. per sq. in., when calling for bids. Busch-Sulzer designed safely below this specified maximum of 85 lb.—the 30-day test showing an actual m.e.p. of 60.7 lb. Just what is reasonably conservative, taking into consideration that the engine cost increases as the m.e.p. decreases, is, of course, a matter of opinion. Busch-Sulzer practice is to rate on service requirements rather than on engines, starting with about 100 lb. m.e.p. for intermittent duty at varying loads and dropping to about 90 lb. m.e.p. for such heavy duty as single screw direct propulsion of commercial ocean going vessels. As Busch-Sulzer similar 2-cycle heavy duty engines rated on about 90 lb. m.e.p. have established satisfactory service records over a period of years, the SAWOKLA engine may be conservatively stated to be about 10 per cent larger than its rated 3000 b.hp. at 90 r.p.m. Further, as 95 r.p.m. is the propeller speed for some of the Shipping Board steamers now being converted to motorships, advantage may be taken of the still higher power rendered available by normally operating the Busch-Sulzer engines at 95 r.p.m., since the power increases directly as the engine speed, and the engine is designed for safe operation up to 105 r.p.m. with piston speed of 910 ft. per min. Additional ship speed may be thus gained.

The low fuel consumption of 0.406 lb. per b.hp. hour (corrected to 18,500 B.t.u.) averaged during the official 30-day shop test establishes not only proper design but complete, clean combustion. This is essential to continued satisfactory operation of the Diesel, where boiler fuel is burned within the cylinder of the engine. Of lesser importance is the actual fuel saving per year, or for the life of the motorship.

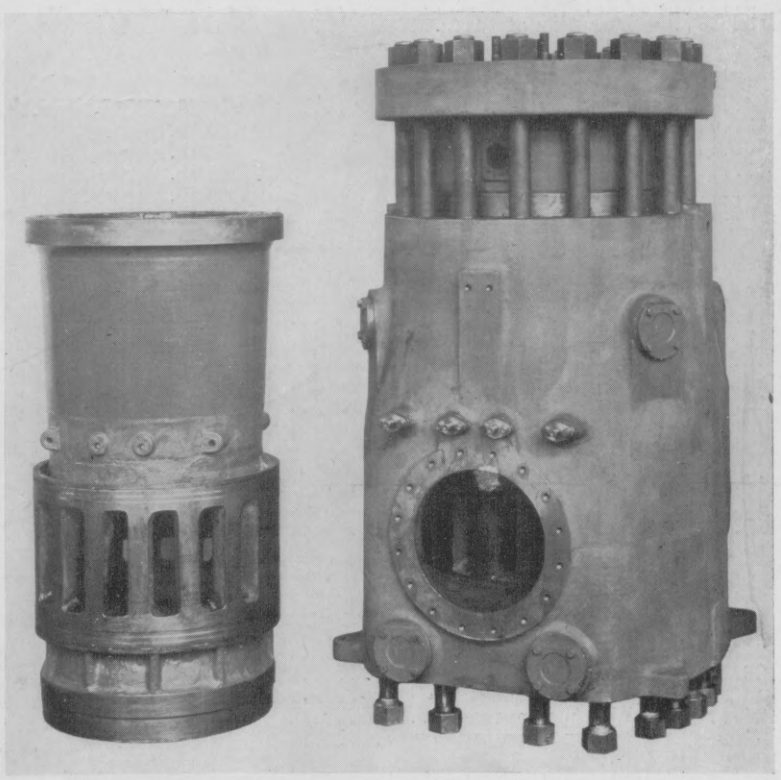
Fuel meeting fully the requirements of the Shipping Board specifications was used throughout the test. The first part of the run was made with a comparatively light gravity oil, as this is beneficial to the first wearing in of the cylinder liners. During the last part of the run, without changes to atomizers or any other adjustments, the fuel tested 83 sec. Saybolt Furol viscosity at 77 deg. Fahr., but no appreciable difference was noted in engine performance.

Busch-Sulzer has always followed the practice of testing all engines at its works with positive hydraulic brakes. Such test equipment in hand at the time the Shipping Board order was placed included brakes of 3000 hp. capacity, but not suitable for so low an operating speed as 90 r.p.m. Officials of the Shipping Board kindly offered to loan available electric generators for test purposes; but, following its custom, Busch-Sulzer included, in preparation for tests, the purchase of a 9000 H.P. Heenan Froude test brake, of necessity imported from England as not manufactured in so large a size in this country. Fortunately the Chief Engineer of Heenan Froude was present at St. Louis to check the calibrations of the brake in the presence of the Shipping Board officials, prior to the test.

(*Continued on page* 278)



Cylinder head shows simplicity



Cylinder and cylinder liner

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Shipping Board's Official Test Report

30-Day Full Load Test on First Busch-Sulzer 6-Cylinder, 30 in. x 52 in. Single-Acting 2-Cycle Diesel

	Item	Maximum Reading	Minimum Reading	Average Reading
1	Load	100 per cent	100 per cent	100 per cent
2	Barometer	29.63 in.	29.02 in.	29.38 in.
3	Duration	30 days	30 days	30 days
	Pressures			
4	Injection air	856.3 lb. per sq. in.	825.0 lb. per sq. in.	843.6 lb. per sq. in.
5	Jacket cooling water	12.0 lb. per sq. in.	10.0 lb. per sq. in.	10.4 lb. per sq. in.
6	Piston cooling water	41.0 lb. per sq. in.	35.0 lb. per sq. in.	38.5 lb. per sq. in.
7	Lubricating oil	10.0 lb. per sq. in.	10.0 lb. per sq. in.	10.0 lb. per sq. in.
8	Scavenge air	1.77 lb. per sq. in.	1.5 lb. per sq. in.	1.68 lb. per sq. in.
9	Lubricating oil to crossheads	258.3 lb. per sq. in.	228.8 lb. per sq. in.	248.9 lb. per sq. in.
	Temperatures			
10	Atmosphere	68.8 deg. Fahr.	31.8 deg. Fahr.	47.9 deg. Fahr.
11	Engine room	72.8 deg. Fahr.	62.2 deg. Fahr.	69.0 deg. Fahr.
12	Fuel oil	84.0 deg. Fahr.	52.0 deg. Fahr.	62.5 deg. Fahr.
13	Cooling water inlet	91.0 deg. Fahr.	79.3 deg. Fahr.	86.2 deg. Fahr.
14	Cooling water outlet	122.8 deg. Fahr.	116.4 deg. Fahr.	118.5 deg. Fahr.
15	Exhaust	458.2 deg. Fahr.	397.5 deg. Fahr.	423.7 deg. Fahr.
16	Lubricating oil to crosshead	160.0 deg. Fahr.	150.0 deg. Fahr.	155.0 deg. Fahr.
	Fuel Analysis			
17	High heat value	19,462 B.t.u.	19,173 B.t.u.	19,374 B.t.u.
18	Low heat value	18,267 B.t.u.	18,008 B.t.u.	18,188 B.t.u.
19	Beaumé gravity	28.9 deg.	24.9 deg.	26.8 deg.
20	Saybolt Furol (at 77 deg. Fahr.)	83 sec.	21 sec.	46.5 sec.
21	Sulphur content	0.83 per cent	0.54 per cent	0.66 per cent
22	Flash (Pensky-Martens)	281 deg. Fahr.	212 deg. Fahr.	238 deg. Fahr.
23	Burning point	——	——	——
	Fuel Consumption			
24	Lb. per hr	1273.02 lb.	1223 lb.	1244 lb.
25	Lb. per i.hp.-hr	0.3293 lb.	0.294 lb.	0.307 lb.
26	Lb. per b.hp.-hr.*	0.4174 lb.	0.396 lb.	0.406 lb.
	Power and Efficiency			
27	Engine speed	89.6 r.p.m.	88.9 r.p.m.	89.2 r.p.m.
28	I.hp. power cylinders	4201.7 i.hp.	3865.3 i.hp.	4046.5 i.hp.
29	M.i.p.	84.8 lb. per sq. in.	77.6 lb. per sq. in.	81.5 lb. per sq. in.
30	M.e.p. (calculated)	61.1 lb. per sq. in.	60.3 lb. per sq. in.	60.7 lb. per sq. in.
31	I.hp.† scavenge pumps	278.6 i.hp.	234.4 i.hp.	256.1 i.hp.
32	I.hp.† compressor	303.3 i.hp.	258.4 i.hp.	277.9 i.hp.
33	Brake horsepower	3025.0 b.hp.	3001.7 b.hp.	3012.1 b.hp.
34	Mechanical efficiency	77.9 per cent	71.6 per cent	74.5 per cent
35	Thermal efficiency	32.14 per cent	31.3 per cent	31.8 per cent

Load Tests on Second Busch-Sulzer Engine

	Item	Overload Test Reading	Full Ahead Test Reading
1	Load	110 per cent	100 per cent
2	Barometer	——	——
3	Duration of test	6 hr.	24 hr.
	Pressures		
4	Injection air	900 lb. per sq. in.	850 lb. per sq. in.
5	Jacket cooling water	10 lb. per sq. in.	10.3 lb. per sq. in.
6	Piston cooling water	24 lb. per sq. in.	27.6 lb. per sq. in.
7	Lubricating oil	10 lb. per sq. in.	10 lb. per sq. in.
8	Scavenge air	1.9 lb. per sq. in.	1.75 lb. per sq. in.
9	Lubricating oil to crosshead	183 lb. per sq. in.	180 lb. per sq. in.
	Temperatures		
10	Atmosphere	86.0 deg. Fahr.	85.2 deg. Fahr.
11	Engine room	84.0 deg. Fahr.	85.2 deg. Fahr.
12	Fuel oil	—— deg. Fahr.	—— deg. Fahr.
13	Cooling water inlet	85.0 deg. Fahr.	85.4 deg. Fahr.
14	Cooling water outlet	125.7 deg. Fahr.	120.1 deg. Fahr.
15	Exhaust	468.3 deg. Fahr.	428.4 deg. Fahr.
	Fuel Consumption		
16	Lb. per hr	1398.67 lb.	1272 lb.
17	Lb. per i.hp.-hr	0.324 lb.	0.298 lb.
18	Lb. b.hp.-hr*	0.4154 lb.	0.416 lb.
	Power and Efficiency		
19	Engine speed	87.25 r.p.m.	87.7 r.p.m.
20	I.hp. power cylinders	4322 i.hp.	4274 i.hp.
21	M.i.p.	88.96 lb. per sq. in.	88.2 lb. per sq. in.
22	M.e.p. (calculated)	68.2 lb. per sq. in.	62.1 lb. per sq. in.
23	I.hp.† scavenger pumps	237.6 i.hp.	215.1 i.hp.
24	I.hp.† compressor	287.35 i.hp.	273.5 i.hp.
25	Brake horsepower	3317,2 b.hp.	3006.5 b.hp.
26	Mechanical efficiency	76.7 per cent	70.1 per cent
27	Thermal efficiency	33.1 per cent	33 per cent.

*Corrected to 18,500 B.t.u. †Subtract.

Wear on Cylinder Liners

Cyl. No.	Max.	Min.	Average
1	.004	.000	.0025
2	.009	.004	.007
3	.009	.000	.004
4	.012	.001	.005
5	.006	.002	.005
6	.009	.000	.005

Growth in Cylinder Liners

Cyl. No.	Max.	Min.	Average
1	.002	.001	.0015
2	.003	.002	.003
3	.000	.000	.000
4	.000	.000	.000
5	.006	.002	.004
6	.003	.000	.0015

Brand of Lub. Oil Used

Engine Part	Brand
Power cycl	Vilburine
Scav. pumps	Vilburine
Air comp.	Valvoline
Hand feed	Vilburine
Forced feed	Vilburine

Lub. Oil Consumption

Engine Part	Drops per min.	Coal per 24 hr.
Each cyl.	80.8	15.3
Scav. pumps	2	—
Air comp.	6.5	0.141
Hand feed	—	0.866
Forced feed	—	5.3

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Shipping Board's Official Test Report

Varying Load Tests on First Busch-Sulzer 6-Cylinder, 30 in. x 52 in. Single-Acting 2-Cycle Diesel

	Item	Overload Test Reading	Three-quarter Load Test Reading	Full Astern Test Reading
1	Load	110 per cent	75 per cent	50 per cent
2	Barometer	——	——	——
3	Duration of test	6 hr.	4 hr.	2 hr.
	Pressures			
4	Injection air	916.7 lb. per sq. in.	750.0 lb. per sq. in.	650.0 lb. per sq. in.
5	Jacket cooling water	12.0 lb. per sq. in.	12.0 lb. per sq. in.	9.0 lb. per sq. in.
6	Piston cooling water	38.0 lb. per sq. in.	34.0 lb. per sq. in.	21.0 lb. per sq. in.
7	Lubricating oil	10.0 lb. per sq. in.	10.0 lb. per sq. in.	10.0 lb. per sq. in.
8	Scavenge air	1.6 lb. per sq. in.	1.1 lb. per sq. in.	.88 lb. per sq. in.
	Temperatures			
9	Atmosphere	73.3 deg. Fahr.	62.0 deg. Fahr.	47.0 deg. Fahr.
10	Engine room	72.7 deg. Fahr.	71.5 deg. Fahr.	65.0 deg. Fahr.
11	Fuel oil	80.0 deg. Fahr.	80.0 deg. Fahr.	78.0 deg. Fahr.
12	Cooling water inlet	82.0 deg. Fahr.	80.0 deg. Fahr.	88.0 deg. Fahr.
13	Cooling water outlet	124.8 deg. Fahr.	117.0 deg. Fahr.	121.6 deg. Fahr.
14	Exhaust	501.1 deg. Fahr.	391.6 deg. Fahr.	308.3 deg. Fahr.
15	Lub. oil to crossheads			
	Fuel Analysis			
16	High heat value	19,374 B.t.u.	19,374 B.t.u.	19,374 B.t.u.
17	Low heat value	18,188 B.t.u.	18,188 B.t.u.	18,188 B.t.u.
18	Beaumé gravity	24.9 deg.	24.9 deg.	24.9 deg.
19	Saybolt Furol (at 77 deg. Fahr.)	83.0 sec.	83.0 sec.	83.0 sec.
20	Sulphur content	.72 per cent	72.0 per cent	.72 per cent
21	Flash (Pensky-Martens)	281.0 deg. Fahr.	281 deg. Fahr.	281 deg. Fahr.
22	Burning point	——	——	——
	Fuel Consumption			
23	Lb. per hr.	1434.5 lb.	967 lb.	665 lb.
24	Lb. per i.hp.-hr.	0.3364 lb.	0.319 lb.	0.306 lb.
25	Lb. per b.hp.-hr.*	0.4244 lb.	0.419 lb.	0.440 lb.
	Power and Efficiency			
26	Engine speed	89.6 r.p.m.	82.6 r.p.m.	72.0 r.p.m.
27	I.hp. power cylinders	4263.5 i.hp.	3031.5 i.hp.	21.7 i.hp.
28	M.i.p.	85.6 lb. per sq. in.	66.1 lb. per sq. in.	54.1 lb. per sq. in.
29	M.e.p. (calculated)	66.7 lb. per sq. in.	49.5 lb. per sq. in.	37.7 lb. per sq. in.
30	I.hp.† scavenge pumps	256.15 i.hp.	207.5 i.hp.	147.9 i.hp.
31	I.hp.† compressor	333.1 i.hp.	245.3 i.hp.	182.6 i.hp.
32	Brake horsepower	3322.3 b.hp.	2271.5 b.hp.	1513.0 b.hp.
33	Mechanical efficiency	77.92 per cent	74.9 per cent	69.7 per cent
34	Thermal efficiency	30.47 per cent	30.8 per cent	29.8 per cent

Explanatory Notes Relative to Official Report of Engine Tests

Engine Stops

The performance of both the first and the second of the Busch-Sulzer engines is eminently satisfactory and the builders have done a fine piece of work with them.

During the 30 day test with the first engine, only one stop occurred, but this was not of a serious nature and the trouble was soon overcome. On the seventh day of the test a stop of 1 hr. 26 min. took place owing to the fuel valve of No. 1 cylinder sticking. This is an occurrence likely to happen to any new engine and the trouble was easily remedied. Moreover the time stopped was made up after the official 30 days' running so that the first engine actually carried out her full test.

Measurements of Wear

Cylinder liners were measured at three different points, two radial measurements being taken at each point. The average wear in the table opposite represents the mean of six measurements. It was found, after the test, that one piston cooling telescopic tube had a small hole worn in it, probably due to unalignment. All showed some wear.

Engine scavenge pumps and air compressor cylinders were found to be in excellent condition.

Load Tests on First Busch-Sulzer Engine

	Item	Quarter Load Test Reading	Full Astern Test Reading
1	Load	25 per cent	100 per cent
2	Barometer		
3	Duration	2 hr.	1 hr.
	Pressures		
4	Injection air	625 lb. per sq. in.	850 lb. per sq. in.
5	Jacket cooling water	9 lb. per sq. in.	11 lb. per sq. in.
6	Piston cooling water	20 lb. per sq. in.	38 lb. per sq. in.
7	Lubricating oil	10 lb. per sq. in.	10 lb. per sq. in.
8	Scavenge air	0.38 lb. per sq. in.	1.75 lb. per sq. in.
9	Lubricating oil to crossheads		
	Temperatures		
10	Atmosphere	46.0 deg. Fahr.	45.0 deg. Fahr.
11	Engine room	66.0 deg. Fahr.	63.0 deg. Fahr.
12	Fuel oil	78.0 deg. Fahr.	70.0 deg. Fahr.
13	Cooling water inlet	90.0 deg. Fahr.	88.0 deg. Fahr.
14	Cooling water outlet	104.9 deg. Fahr.	124.5 deg. Fahr.
15	Exhaust	211.6 deg. Fahr.	413.3 deg. Fahr.
	Fuel Consumption		
16	Lb. per i.hp.-hr.	356 lb.	1515 lb.
17	Lb. per b.hp.-hr*	0.288 lb.	0.353 lb.
18	Lb. per b.hp.-hr.	0.465 lb.	0.44 lb.
	Power Efficiency		
19	Engine speed	56.4 r.p.m.	88.5 r.p.m.
20	I.hp. power cylinders	1237.2 i.hp.	3721.5
21	M.i.p.	39.6 lb. per sq. in.	75.5
22	M.e.p. (calculated)	24. lb. per sq. in.	60.6
23	I.hp.† scavenge pumps	60.5 i.hp.	257.7
24	I.hp.† compressor	122. i.hp.	356.8
25	Brake horsepower	752 b.hp.	2986.8 b.hp.
26	Mechanical efficiency	60.8 per cent	80.2
27	Thermal efficiency	27.8 per cent	29.8 per cent

*Corrected to 18,500 B.t.u. †Subtract.

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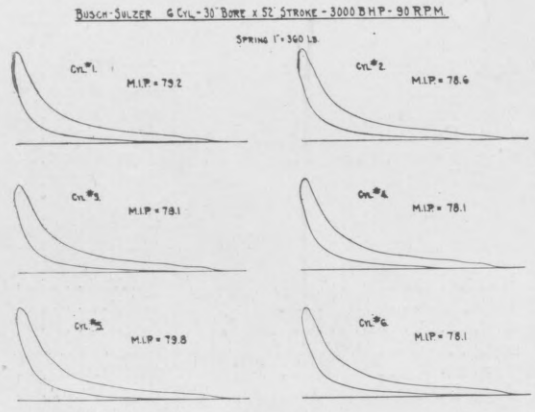
Development of Ms. Sawokla's Main Engine

(*Continued from page* 275)

"Froude Brakes make no Mistakes" is a Busch-Sulzer maxim. The set of cards illustrated show a mechanical efficiency of over 78 per cent. The real test of an engine, however, comes with the years; and Busch-Sulzer looks forward to the record of ms. SAWOKLA with the confidence of past successes with honestly built liberal engines.



Typical indicator cards

But of far more importance than SAWOKLA'S engine is the ship herself and her eleven consort motorships, the beginning of a new American Merchant Marine, founded on highest economy of operation, to endure in the unequal fight against foreign shipping.

Six months is required for the forging of a single crankshaft for these large engines and a year to convert a ship. But with the program for changing a fleet of these steamers to motorships (with approximate reduction of fuel consumption from 35 to 13 tons per day) well under way, and with orders placed to permit quantity production, a Busch-Sulzer engine of SAWOKLA type could be shipped every month, and overall conversion costs materially reduced.

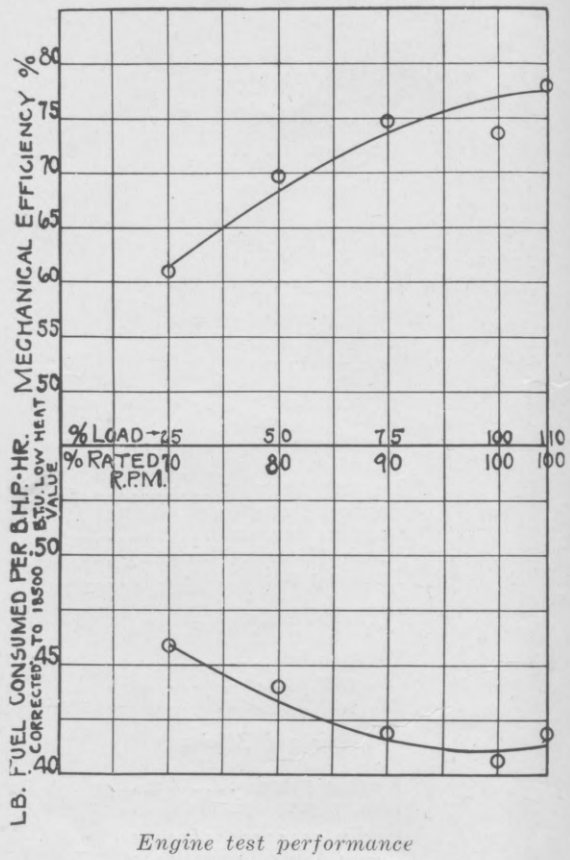
The Shipping Board has done a great creative work in placing scattered orders for initial engines with various builders, which, in 2 years, has far advanced the art of Diesel building in the United States. This development work has been costly. Its value, and justification lie in subsequent orders.

Busch-Sulzer S. B. Engine Performance

	AS OFFERED OR GUARANTEED	PERFORMANCE 30-DAY TEST RESULTS
Fuel consumption — guaranteed per b.hp. hour	0.43 lbs.	0.4134 lbs.
Fuel consumption equivalent, net heat value	....	.406 lbs.
Mech. eff., full load	72.0	74.5
Mech. eff., 110 per cent load	72.0	77.9
M.e.p. at rated load	85.0	60.7
Specified engine capacity	3000 b.hp.	....
Engine capacity at 90 r.p.m., 85 lb. m.e.p.....	....	3160 b.hp.
Engine capacity at 95 r.p.m., 85 lb. m.e.p.	....	3330 b.hp.
Engine capacity at 95 r.p.m., 90 lb. m.e.p.	....	3400 b.hp.
Weight of engine complete, without spares, starting tanks, oil or water ..	1,080,000 lb.	868,000 lb.
Gain on specification	....	19.65 per cent.
Weight per hp. at 3000 hp. rating	360 lb.	289.3 lb.
Actual weight at basis rating 3330 b.hp. at 95 r.p.m. and 85 lb. m.e.p.	....	260 lb. per b.hp.
Actual weight basis rating 3400 b.hp. at 95 r.p.m. and 90 lb. m.e.p.	....	256 lb. per b.hp.

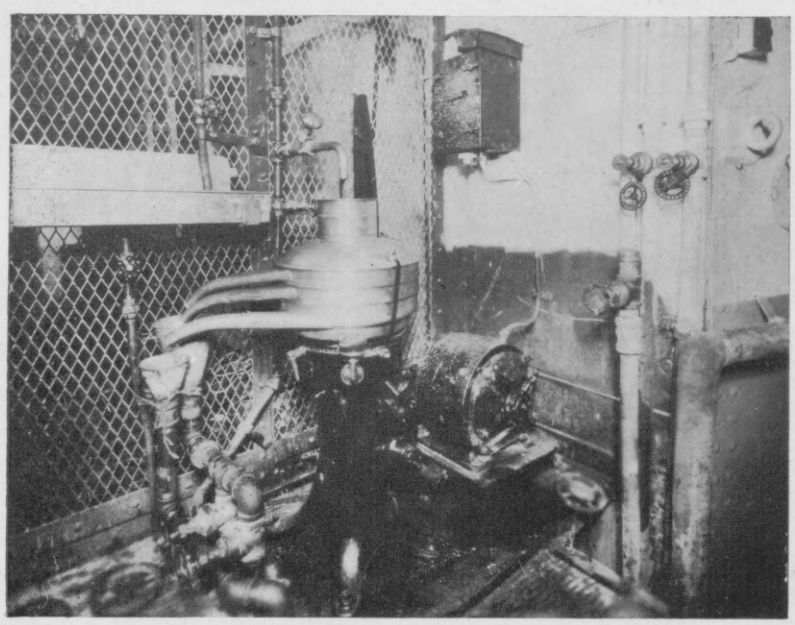
A majority of the ships carrying our commerce is operated by the United States Shipping Board, which accordingly becomes the logical purchaser to derive benefit from this development.

The demand for higher speed cargo carriers on competitive routes calls for new ships; but emphasizes the coming obsolescence of the large fleet of steamers of the SAWOKLA type. Converted to motorships of from 11 to 12 knots speed, 100 of these efficient ships would be available within

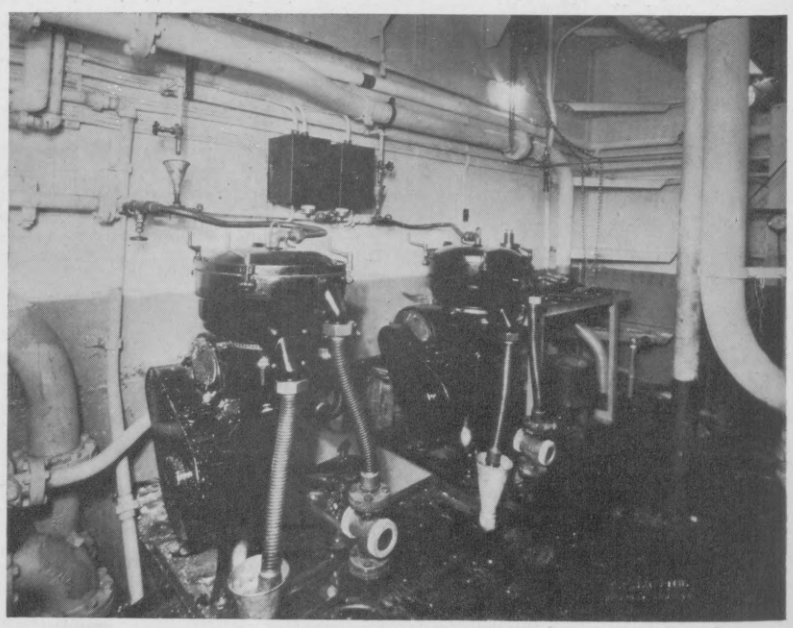


Engine test performance

two years, after the program was inaugurated. Supported by the economy of such a motorship fleet, the permanence of the American Merchant Marine would be established, the reduction in operating losses would assist the program for new and faster ships (which normally would require a longer time, including authorization, for execution) and the ultimate aim—that efficient ships of American registry shall serve the needs of industrial America in securing a world outlet for its rapidly increasing surplus production—would be assured.



Purifier for lubricating oil service



Two purifiers for fuel oil service

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Thirty-three Big Motor Patrol Boats

Possibilities of Fresh Field for Diesel Engines, Culminating in Motor Destroyers, Seen in Completion of New Fleet

CONSTRUCTION of a fleet of 33 twin-screw motor patrol boats for the U. S. Coast Guard represents a noteworthy piece of shipyard operation, and considerable interest was aroused in shipbuilding circles when the contract was placed in May of last year with American Brown Boveri Electric Corp., Camden, N. J., to undertake the work. The contract price was $63,000 per boat and it was required of the builder that the vessels should be completed in batches, and in accordance with these terms six of the vessels were to be completed before the end of last year; seven boats before the end of January of this year; eight boats before the end of February, and the remaining before April 15th. This contract schedule has been well adhered to and the whole operation of construction is of such important nature that we feel justified in drawing the particular attention of our readers to it.

Propelled by twin Winton Diesels totaling 300 hp., and having a length overall of 125 ft., with a loaded displacement of 220 tons, these vessels represent not only a distinctly new thought in naval construction but also a problem involving a considerable amount of detail work in the shipyard. When we speak of a new thought in naval construction we do so advisedly for the reason that if at some time in the future torpedo boat destroyers, attached to fleets, will be Diesel propelled, then right here in these motor patrol boats are the precursors of the type.

Turning back through the pages of the history of naval construction, those of us who remember the evolution of the torpedo boat will recall that such ships started first as small launches carried by larger ships in many cases, and using a spar torpedo. From there the development went on through torpedo boat destroyers, which latter have now increased in size until they are virtually small light cruisers. The light cruiser similarly has altered in role until it is now a large heavily armed torpedo boat destroyer. . . . This is past history and is mainly written around the development of the turbine engine. The European war brought many new craft into being and among them the subchaser and the coastal motorboat. The subchaser was moderately fast and lightly armed, the coastal motor boat was extremely fast and armed with torpedoes. She was, in fact, a modern replica of the old time torpedo boat.

Characteristics of Motor Patrol Boats

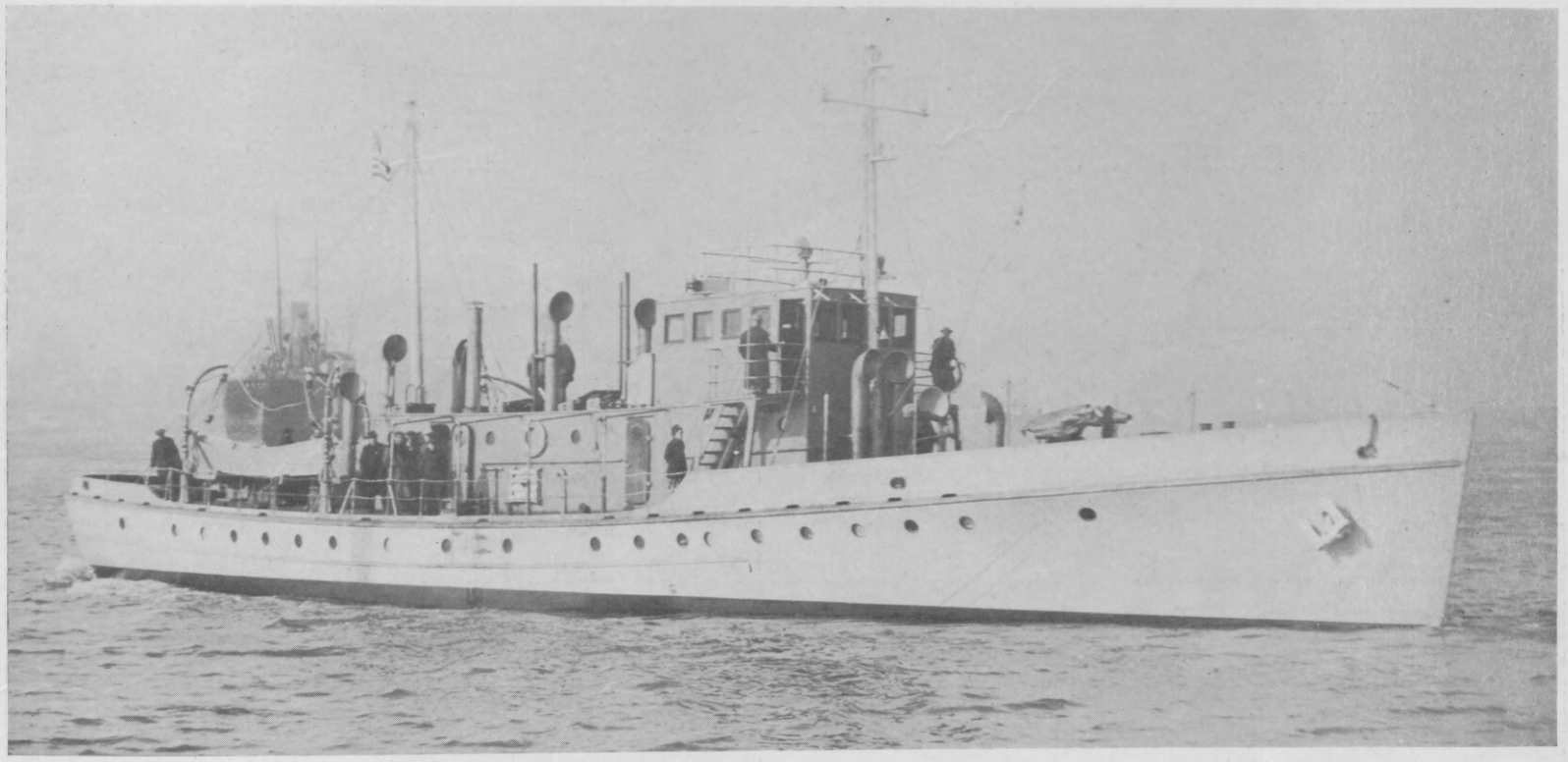
Length overall	125 ft. 0 in.
Length b.p.	120 ft. 0 in.
Depth mld.	12 ft. 0 in.
Beam molded	21 ft. 0 in.
Beam molded at l.w.l.	23 ft. 6 in.
Draft forward	5 ft. 0 in.
Draft aft	8 ft. 6 in.
Displacement to l.w.l.	220 tons
Block coefficient	0.394

Now Coast Guard requirements have brought into being a fleet of 33 patrol boats. These admittedly are not fast, but remember that they have been designed for a particular purpose, that they are actually the first of their type, and that the type is capable of considerable development. Remember too, that the success of such boats depends entirely on the fitting of internal combustion engines for propulsion. We may watch their performance carefully therefore, for future development.

The biggest advance over subchaser construction, as far as shipbuilding technique is concerned, is not only the increase in size, but also the fact that steel construction has been used throughout. Diesel engines of Winton type have been used for propulsion for reasons of compactness, efficiency and economy. A glance at the engineroom arrangement shows how well this has been carried out. Two main 6-cylinder Winton Diesels, each rated at 150 b.hp. and fitted with reversing levers are connected each to a propeller. An 8 kw. generator set is used for lighting and there is also an arrangement of 12 Philco storage batteries of 200 amp. hr. capacity.

This battery installation consists of 16 cells, 200 amp. lead plate batteries, 32 volt system. There are 6 trays of 5 and 6 volts and one of 2 volts. These batteries supply all the electrical requirements when the generator is not running. The usual load consists of lighting, radio and refrigerator plant, but the battery is large enough to run the fire pump for about 1 hour before it is totally discharged.

There are two lubricating oil pumps, an auxiliary air compressor which is a Winton-Westinghouse unit, a fire pump driven by a 7½ hp. motor. A Lux-Rich CO_2 fire extinguishing system takes care of the engineroom and ship. Other fittings include three watertight bilge educters and one vertical fire tube heating boiler.



One of a fleet of 33 big Diesel propelled Patrol Boats built specially for the U. S Coast Guard

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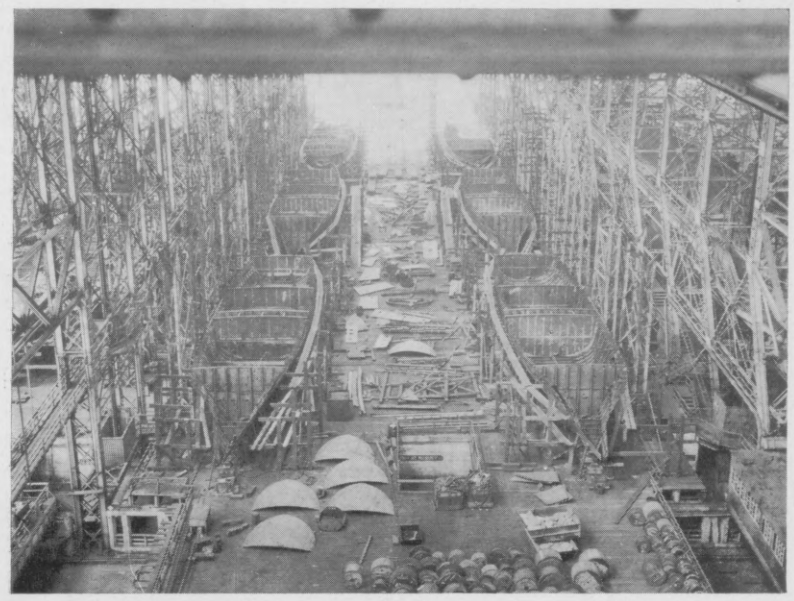
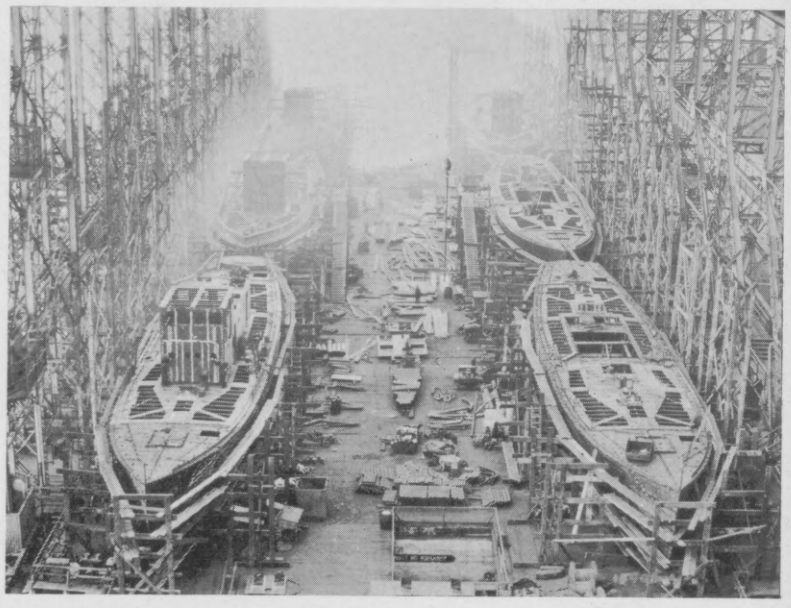


Sept. 15, 1926. *Ships in frame*



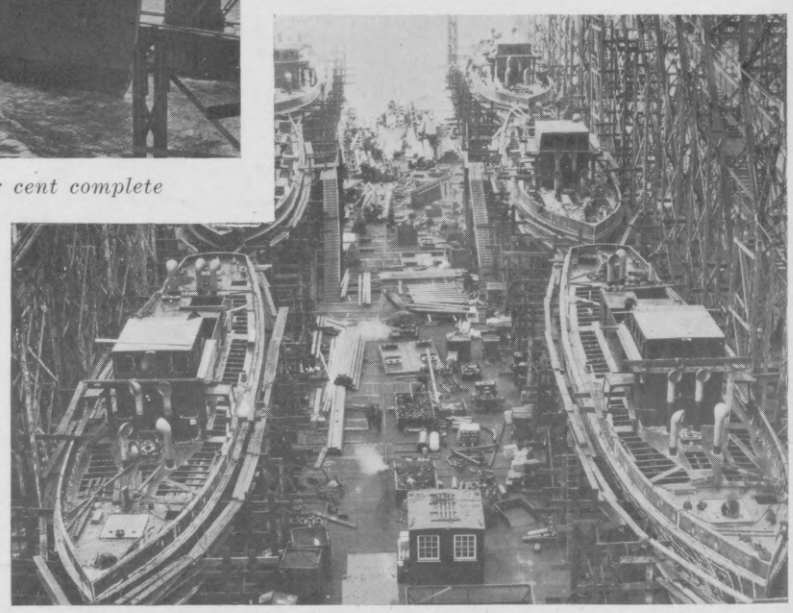
Nov. 15, 1926. *Hulls plated*

Progress Work on Fleet of Built at Camden, N. J.

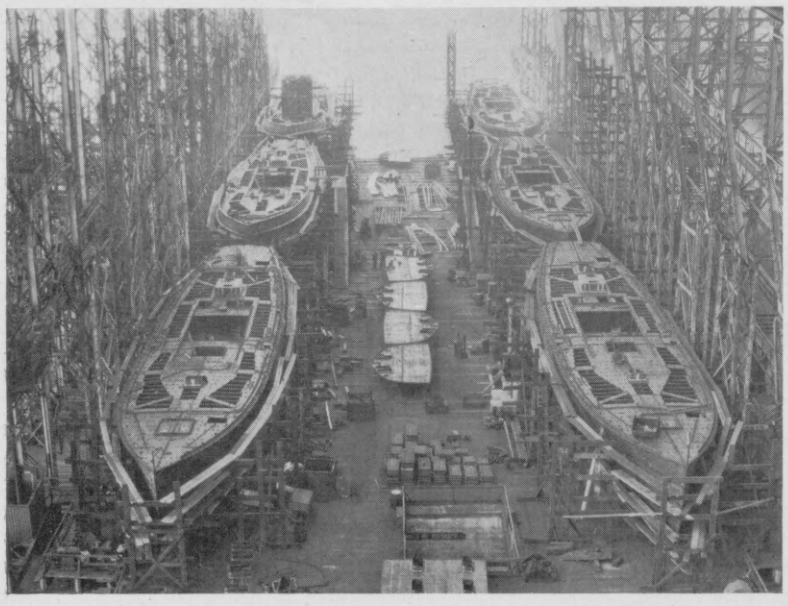
Launched 90 per cent complete

33 Diesel Patrol Boats for U. S. Coast Guard

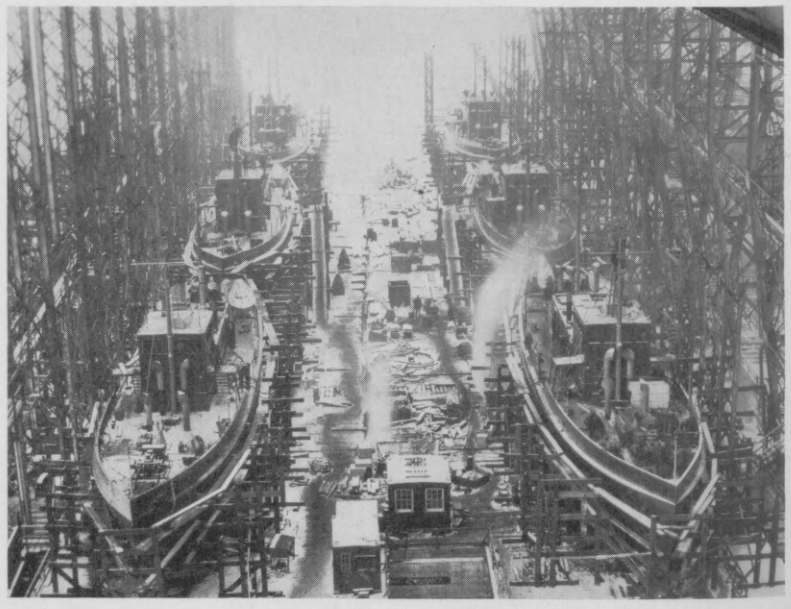
Oct. 15, 1926. *Partly plated*



Dec. 15, 1926. *Working on deck fittings*



Nov. 1, 1926. *Start made with superstructure*



Jan. 15, 1927. *Ready for launching*

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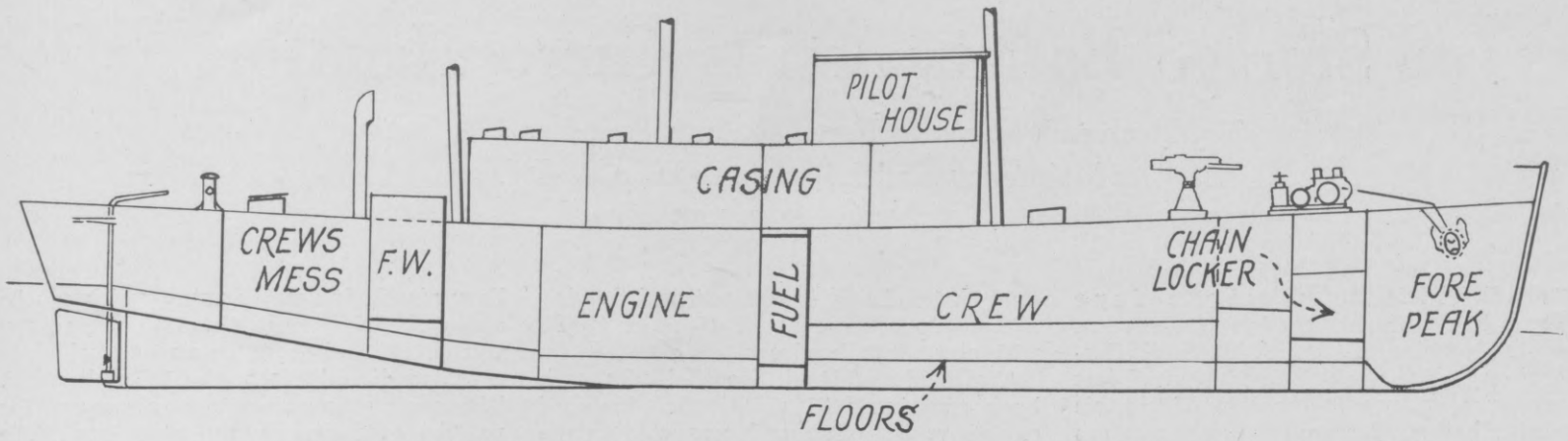


Inboard outline profile of 125 ft. Diesel engined Coast Guard Patrol Boats

Deck machinery is all electric and includes a Hyde windlass forward with Cutler-Hammer control. This is driven by a 7½ hp. Electro Dynamic motor. A strong towing bitt is fitted aft.

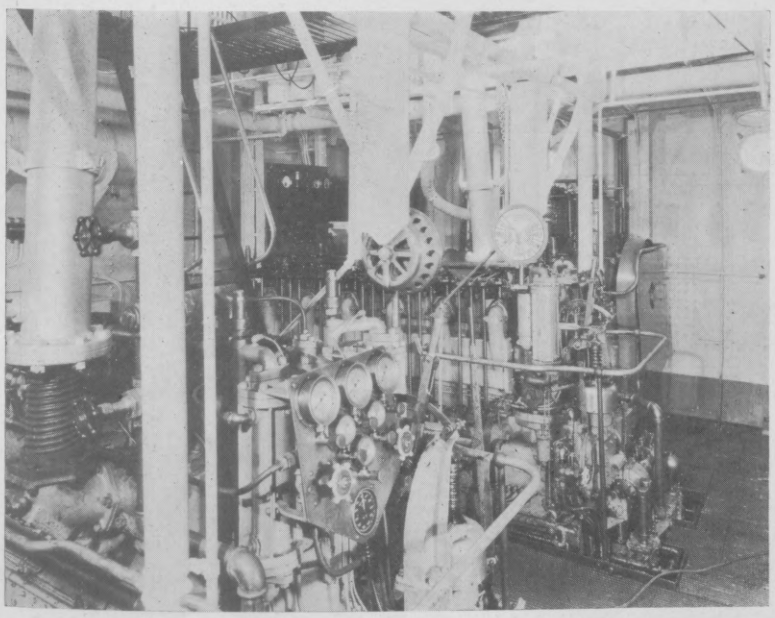
In the engine casing there is a small whistle air compressor driven by a 1/3 hp. Leland motor.

The hulls are of all steel construction and the main frames are 5 in. x 3 in. x ⅜ in. angles spaced 24 in. Strong webs 12 in. deep with double 3 in. x 3 in. x ⅜ in. angles are fitted in the engineroom amidships. There are reverse frames in the engineroom only and these extend completely across the floor. Elsewhere the floors have a 3 in. flange at the top and are continuous from side to side. The hull presents fine lines with long entrance and run, and practically no parallel middle body. The sheer is sharp forward running down gradually aft. The stem is sloping and the forefoot nicely rounded, while aft there is a big rise of keel from just abaft midships and ending at the bottom of the transom stern. There is a large double plate deadwood, or skeg, aft arranged for the purpose of adding to the vessel's steering qualities. A deck house amidships covers the engineroom, all entrances and contains officers crew's washrooms and toilets. A pilot house and navigating room with wing bridges is located on top of the deck house and at its extreme forward end. This contains steering gear, mechanical telegraphs and radio cabinet. A compressed air siren and searchlight is arranged on top of the wheelhouse.

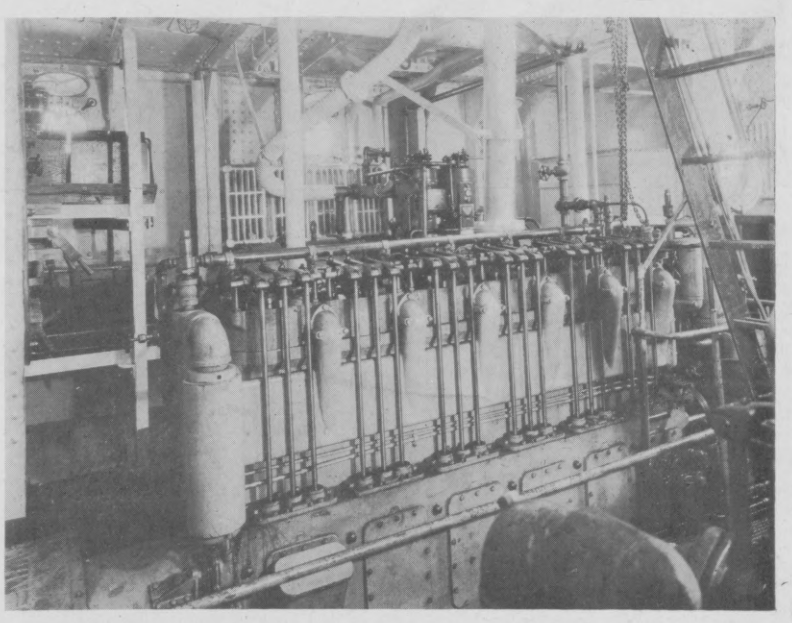
The crew and officers are accommodated on a second or lower deck forward; the wardroom is abaft the engine space. Fuel oil cross bunker of 6650 gal. capacity is arranged forward of the engineroom.

The ships have been built on two large slipways of the builders and an idea of the method in which they have been put together may be obtained from the progress pictures which we publish elsewhere. An order of this kind is naturally an excellent opportunity for fabrication work and the whole of the hull erection had been carried out in orderly sequence on these lines. Six ships were accommodated on each slipway. The steel work was all placed in position bolted up and riveted, as the picture shows. The deck is part steel and part wood, as will be seen. The sterns are of peculiar type somewhat reminiscent of the subchasers and they are constructed on a single dished plate. The superstructures were fabricated complete, away from the ship. They were lifted on whole and placed in position. The special design and arrangement of the superstructure made it convenient to do this.

Work proceeded simultaneously on all six ships on each slipway and then the ship nearest the water was prepared for launching. Through launchways were used the whole length of the three vessels. Each vessel was launched 90 per cent complete, as the picture indicates, and was then fitted out in the wet basin alongside the slips. On Feb. 1st. there were no less than 13 of the vessels in the fitting-out basin, in addition to which, one of the Diesel-electric ferries built by the Camden plant for service in New York was also in the final stages of completion. The ships completed represent a smart workmanlike appearance. Construction of the complete fleet has involved a large amount of detail work and has been carried out very thoroughly by the builders.



Engine room view showing controls



Engine room view from starboard side

Vincent Astor's Huge Diesel Yacht

Krupps of Kiel, Germany, are building a twin-screw motoryacht for Vincent Astor of New York which, powered by Sulzer Diesels of 3000 s.hp. to give a speed of 16 knots, will be one of the largest motoryachts in the world. Theodore Ferris is the designer and J. K. Ingham of his staff is supervising the construction in Germany. Cox & Stevens are the interior decorators. Displacing some 2700 tons, this new yacht will have a length o.a. of 263 ft. 10 in., beam mld. of 41 ft. 6 in. and mean draft of 16 ft. She will have a cruising radius of 16128 nautical miles.

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Storage Battery Assists Cargo Handling

Ms. Steelvendor Secures Port Economy, Speed and Reduction of Maintenance with Battery to Help Peak Loads

By Dan C. McKay

STEELVENDOR, one of the four Welland Canal type freighters in the service of the U. S. Steel Corporation on the Great Lakes, acquired last summer a unique installation of electric storage battery for easing the generators during the loading and discharging of cargo with her two 5-ton Brownhoist cranes. She is one of the motorvessels built by the Federal S. B. & D. D. Co., in 1923 and is registered in the name of the U. S. Steel Products Co., which is the export subsidiary of the Steel Corporation. She measures 250.3 ft. overall, 42.9 ft. breadth and 17.2 ft. depth of hold, with a deadweight capacity of 2078 tons, and has a 6-cyl. McIntosh & Seymour engine of 750 b.hp. for propulsion. During the navigation season on the Lakes she operates between Chicago and Montreal, and—like all Lake boats—spends little time at terminals.

A small Mianus oil engine direct connected with a 5 kw. 110 volt generator was part of the original machinery installation and, located on the main platform starboard side forward, performed such duties as furnishing light while in port, bilge pumping, etc. It was all that its term of auxiliary generating unit implies. Having been in operation for three seasons on the Lakes it was removed, leaving a clear floor space about 15 ft. x 20 ft. with about 9 ft. headroom.

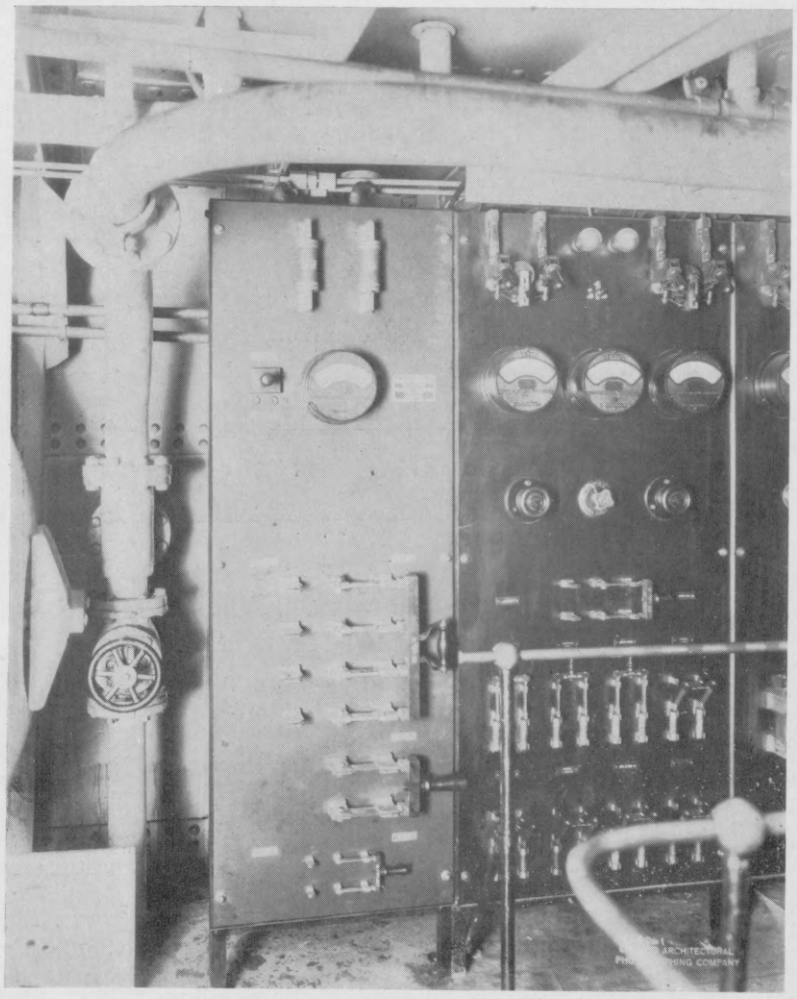
Two banks of Exide Ironclad cells, each bank containing 55 units, were installed one above the other and connected to the switchboard by means of an additional panel about 18 in. wide added to the main board. This panel contains the main battery switch for connecting with the 230 volt panel of the main generators and the 4-pole double-throw switch for either series connection with the main 230 volt power panel or parallel hook-up with the 115 volt lighting circuit panel.

The main electrical installation of Ms. STEELVENDOR is served by two 3-cyl. 90 hp. Worthington airless-injection engines, each direct-connected with a Diehl 60 kw. 240 volt compound wound generator. The following are the various electrically driven auxiliaries: 240 g.p.m. ballast pump, 240 g.p.m. bilge pump, 400 g.p.m. centrifugal circulating pump, 150 g.p.m. auxiliary circulating pump, two 125 g.p.m. rotary lub. oil pumps, De Laval separator, 40 g.p.m. lub. oil drain pump, ½ ton ice machine, turning gear for main engine and 7½ kw. motor-generator set. These are all operated at 230 volts with the exception of the auxiliary circulating water pump which can be operated either from the 115 volt or 230 volt circuit and the gyro compass which is operated directly from the 115 volt panel. The main generators are arranged for parallel operation on the main bus. The lighting circuit is taken care of by the motor generator, which reduces the voltage from the main units to the required amount.

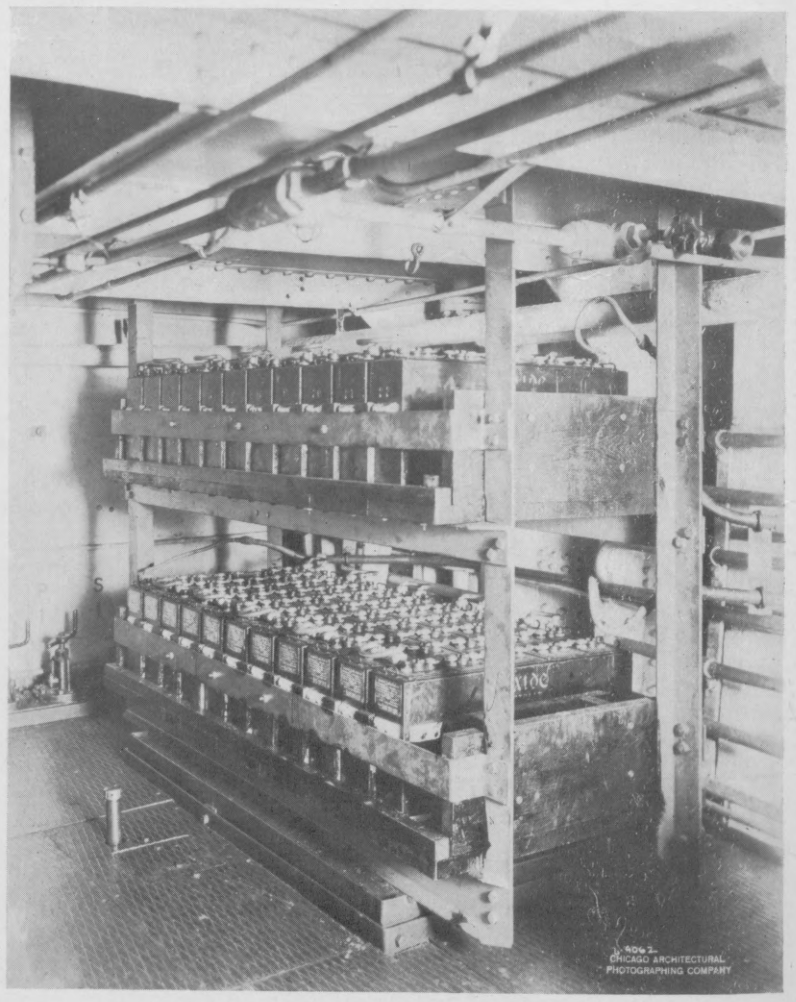
During the first 2½ years of operation when the generators alone were used for power for cargo handling it was always necessary to parallel 2 units. The 5-ton cranes have 65 hp. motors for hoisting and when both cranes start to hoist simultaneously the load runs up from 50 amp. to 500 amp. which is quite a swing for any machine.

Due to the tendency of crane operators to run the hoists on one or two points of the starting handles, the starting loads which are always higher than normal full speed operation cause greater overload than might be expected. There being no open season on crane operators other means were adopted to ease the generators, viz. batteries.

Such severe service as above mentioned at regular and frequent loading and dis-



Battery panel on Steelvendor's switchboard



Ms. Steelvendor's two banks of storage batteries

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charging periods naturally shows up in the labor required to keep the generating units in good order. Let us assume that one crane is hoisting and the other idle, the governors well open and both generating units well loaded. Crane No. 1 stops and to accommodate the sudden increase in revolutions due to load decrease the engine governors shut off nearly all the fuel, because the normal port load of engine room auxiliaries is only about 50 amp. Let us say that when the governors have the fuel supply at the minimum, crane No. 2 starts a heavy hoist. Then the big peak load causes the generators to slow down, the governors fly open, the engines smoke, labor and knock, and it is some few seconds before normal running conditions are restored. This happens many times during a day's operation, and because of the frequent periods of loading and discharging on a ship of the STEELVENDOR type it is even more than a nuisance.

With the new system a different story is to be told. One generator can be dispensed with, the other being quite sufficient with the batteries floating on the main bus. During peak loads the batteries feed into the line, preventing overloading of the generator. At the termination of the hoist the procedure is reversed, and the generator charges the batteries. The engine operates at constant speed without overloads, and no smoking or knocks are evident.

At night the generators can be shut down and the batteries put on the lighting circuit. This releases all the night watches for overhauling and routine work the following day.

At full charge the battery gravity reads about 1.275. Reducing this to 1.150 pulls about 180 amp. hr. out of it. An ampere-hour meter is part of the equipment, and another instrument for recording the actual work performed by the batteries is a 24 hr. voltage recording meter which keeps an indisputable record of all peak loads, time of placing batteries on equalizing charge, taking them off and putting them on the lighting circuits, etc.

Under normal operating conditions on the Lakes the load is about 150 amp. The generator can give about 250 amp. and when the batteries are floating on the bus they are kept well charged and at a gravity of about 1,260. The variable amperage due to steering gear swings is now unnoticeable in the operation of the generator engine. In the event of a sudden failure of the operating generator unit the circuit breaker for that generator would fly out and the batteries carry the entire load, which they are capable of doing steadily for about 45 min. This would give ample time for the starting of the other machine and placing it in service, eliminating the necessity for a shutdown or in restricted quarters a collision due to failure of power at the steering gear. If the standby set were undergoing repairs the fault in the other machine could be corrected and it could be started again and its service resumed in 45 min.

By means of a special switch the batteries can be quickly charged if required at 115 volts, by charging in parallel through suitable resistance grids, the generator voltage being then reduced to 230 volts.

There are many advantages to such an installation. There is no need for a small Diesel engine of doubtful utility, with attendant upkeep and maintenance. The battery installation is much cleaner and it is noiseless. A saving of fuel is effected while discharging cargo, because charging of batteries is not nearly so expensive as operating two machines. The depreciation, wear and tear and labor required for overhauling the main generating units are cut in half. Batteries require less attention than an auxiliary unit and perform a real service. During the operation of the two generators before the installation of batteries one man had to dance attendance continually on the generators, whereas now he can assist repairing.

Taken all in all the battery installation of STEELVENDOR has worked out very satisfactorily for all hands concerned, and certainly is a great improvement over operating two machines during cargo handling.

A further important use for storage batteries on a well known motorship as an auxiliary and emergency power for the steering gear, is being tried out. This field offers such excellent possibilities that we believe the example will rapidly be followed by the owners of many other motorships now in service.

Equipment Details for Big 14,000 Ton Diesel-electric Tanker

WHEN the tanker DISTRICT OF COLUMBIA is converted from steam to Diesel drive, she will be not only the biggest Diesel-electric ship in the world but also the most completely equipped. Standard Oil Co. of California have determined to make their new ship entirely modern in every respect.

Contract to supply the electric propulsive and auxiliary equipment for the conversion to Diesel-electric drive of the tanker DISTRICT OF COLUMBIA, which will be the largest drive of this type ever installed, has been awarded to the Westinghouse Electric & Manufacturing Company. Preliminary details of this conversion were announced in the March issue of MOTORSHIP.

The DISTRICT OF COLUMBIA was built in February, 1921, by the Baltimore Dry Dock & Ship Building Company. She has a length overall of 450 ft., a beam of 59 ft. and a molded depth of 33 ft. 3 in. The vessel has a total cargo tank capacity of 83,146 barrels and a load displacement of 14,760 tons.

The original propulsive machinery consisted of geared cross compound Parsons turbines driving a single screw. The working steam pressure was 200 lb., developing 2,800 s.hp. at 90 r.p.m. The designed sea speed was 10 knots. All auxiliary equipment was driven by steam.

The new propelling equipment, as we have already announced, comprises four 8-cylinder, 2-cycle Busch Sulzer Diesel engines of 1,000 s.hp. each, four 700 kw. d-c generators direct connected to the engines, and one double armature propelling motor, rated 3,200 hp. at 90/105 r.p.m. Excitation for the generators is supplied by two 175 kw. machines direct connected to each of the outboard Diesel engines. The propelling motor, generators and exciters are of the forced ventilation type.

Auxiliary power, when in port and not discharging cargo, is supplied by one 60 kw. 240 volt generator. A motor-generator set, consisting of a 25 hp. motor and a 15 kw. 115 volt generator, is used for lighting. A 40 kw. 230/115 volt generator, which is directly coupled to a gasoline engine, is provided for emergency purposes. Power for cargo pump motors, which are rated at 125 hp. each, is taken from any one of the four main generators.

Among the larger auxiliary motors are two circulating water pump motors of 60 hp. each, two lubricating oil pump motors also of 60 hp. each, and a fire and bilge pump motor of the same rating. There is a ventilating blower motor of 35 hp., a fuel oil transfer motor of 20 hp. and smaller motors for the sanitary pump, refrigeration plant, lighting and other uses.

The electrical deck equipment comprises one 75 hp. windlass motor and brake with magnetic control, three capstan motors and one warping winch motor, all of 40 hp. each.

There are also two 25 hp. cargo winch motors. All motors of the deck equipment are of water tight construction.

Diesel Tugboat for Gulf Ports

A single screw Diesel tugboat for the International Cement Corp. to be used for towing barges between ports on the Gulf of Mexico and adjacent rivers is now under construction at the Marvel Shipyard, Newburgh, N. Y. The new vessel which has an overall length of 90 ft., a water line length of 82 ft. and beam molded of 21 ft., depth molded of 9 ft. 6 in. and mean draft of 7 ft. 0 in. is powered by a 500 hp. 6-cylinder direct reversible Nelseco Diesel constructed by New London Ship & Engine Co. direct-connected to the propeller shaft. This engine develops its power at 235 r.p.m.

Auxiliaries in the engineroom comprise a 10-12 hp. 2-cylinder Palmer gasoline engine, driving through chain a 5 kw. Electro Dynamic generator and a Nelseco 5 cu. ft. capacity air compressor at one end while at the other end is a Gould 100 g.p.m. rotary fire and bilge pump. There is an emergency electric plant comprising a Kohler 1500 watt gasoline-driven generator set with a starting battery. The fresh water transfer pump is a 20 g.p.m. centrifugal motor driven unit. A 2-stage Worthington air-compressor with 50 cu. ft. capacity, and a Gould 1½ cu. ft. suction reciprocating pump are driven off the main shafting.

The ship is constructed of steel throughout with the exception of the fenders, the joiner work in the main deckhouse and the upper deck and the upper deck house. She has been designed by Cox & Stevens, New York.

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Successful Propellers for Lumber Tugs

Pacific Coast Tugs with Direct Connected Diesels Have Developed Satisfactory Propellers for Towing Heavy Log Booms

TOWBOATS with Diesel propulsion working on the British Columbia coast have a special problem to be solved in their design, if intended for the towing of great log booms for long distances. The problem consists in determining the best co-relation in speed between the fast running Diesel and the necessarily slow turning propeller. In the cases under review careful propeller design has done much to find a solution.

Where logs are to face heavy swells of the open sea they are made up into large "cribs" lashed with heavy wire cables, in appearance like a huge sausage, and often containing upwards of 1,000,000 ft. board measure. Alternatively logs for open sea transportation may be loaded into special barges.

In the protected waters which extend almost the whole length of the British Columbia coast, where shelter is afforded by innumerable islands, the logs are made up into flat "booms" for towing. In these flat "booms" the logs float parallel between lines of boom sticks. The boom sticks are connected with heavy chains. Additional boom sticks at the ends and swifter sticks across the top of the boom, made fast to the boom sticks on either side, hold the logs securely as long as there is not enough sea running to cause the logs to ride over the sticks.

"Booms" are generally made about 60 ft. wide, and where of fir logs they scale on a rough average 40,000 ft. board measure to the section. Each section is marked off by swifter sticks, which, however, do not divide the logs in the boom, but simply ride on top of them to steady them and hold the boom in shape. Swifters are secured by chains to the boom sticks.

The larger tugs will tow from 20 to 50 sections in a boom, depending on the power, and whether the ship is crossing any wide reaches of open water where she might be overtaken by bad weather. The larger tows are usually made up of a number of 5 section to 10 section booms fastened by chains one behind the other.

The principal difficulty in applying a tug's power to the best effect when towing these huge booms literally covering acres of sea, lies in the inherent slow speed of

Tug Sea Wave used for experiments

the tow, 1½ m.p.h. being a good average in smooth water with no wind. Thus the ordinary propeller designed for making headway through the water of at least 5 knots to 6 knots, will not allow an oil engine to turn up its full revolutions when the tug is fast to one of these booms.

It was a comparatively simple matter with the older steam tugs turning their wheels at 100 to 150 r.p.m. to design a propeller of large diameter to work efficiently in practically dead water; but a Diesel engine developing its power at 225 to 350 r.p.m. was quite a different problem.

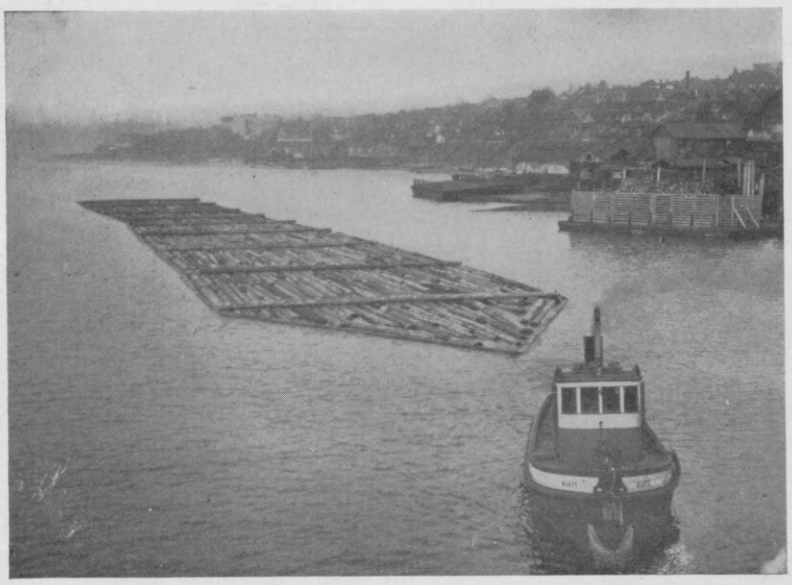
Nevertheless Diesel tugs have multiplied rapidly in the last three or four years and are successfully meeting all competition. Their fuel economies, instant availability, and large cruising radius gave them a decided advantage over the steam craft even before the propeller difficulties were satisfactorily overcome.

The present success has been achieved largely through tugboat owners trying out wheel after wheel, and submitting the results with their own suggestions to propeller designers, till at last they got a wheel that suited.

The first propellers recommended by the engine makers and experienced propeller designers frequently proved unsuitable for log tows, though quite satisfactory for towing barges; but these wheels had never previously held the engines to a steady grind of 1½ m.p.h. for days at a stretch under full power. Now makers and operators are getting a good idea of what the Diesel engine requires.

One of the first lessons learned was that an oil engine must turn at full speed to develop its rated power; it was found, furthermore, that when an engine was persistently and continually overloaded in order to maintain these revolutions or something near them, such conditions were a fruitful cause of engine trouble.

Now the ideal for heavy towing is to have an engine which will turn up to its full revolutions freely with the heaviest tow, and even at a few revolutions in excess when given an overload at a hard pinch. Naturally with this arrangement the revolutions are high when the boat is running light. Some operators throttle the engine down so that its speed does not exceed its normal revolutions, because ½



Small harbor tugs distribute booms to mills

Towing 18 sections of logs into False Creek

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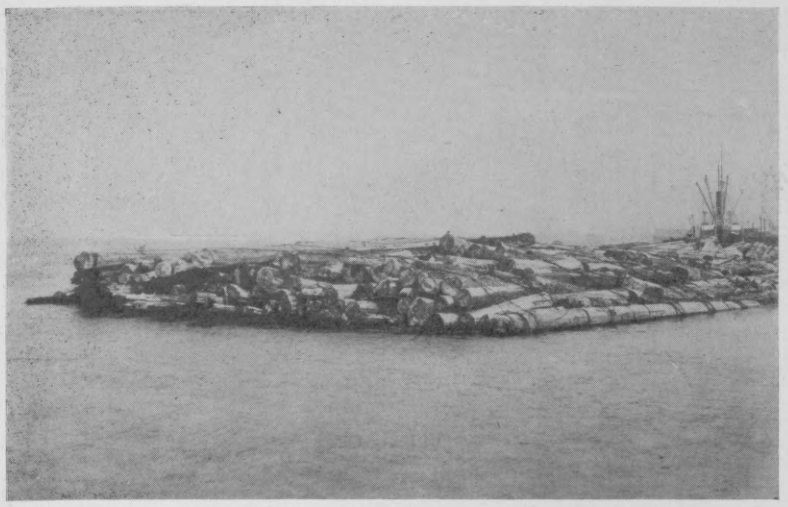
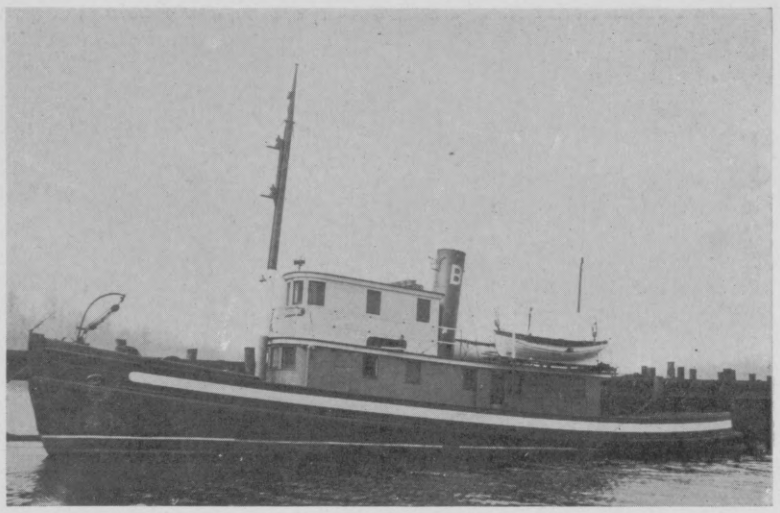


Logs made into "crib" for sea towing



Tug Prosperative has had experimental wheels

knot is neither here nor there in a tug running light, so long as her best power is available when towing. Indeed, as one operator succinctly puts it, "all the machinery she will float will not drive a short heavy tug boat much over 12 knots." On the other hand, some tug owners have found that their engines take quite kindly to speeding up an extra 10 per cent where the load is comparatively trifling. They thus offset to some extent the disadvantage of a towing wheel when the ship is running light.

Both 3-blade and 4-blade propellers are being used successfully. The 3-blade wheel is generally conceded to be slightly more efficient, especially in small sizes, as the blades get better water to work in when turning at high speed; but on the other hand the 4-bladed wheel turns more evenly, and with less tendency to vibration.

The Young & Gore Tugboat Co.'s tug SEA WAVE of Vancouver, B. C., built in 1924 and equipped with a 4-cylinder direct reversing Pacific Werkspoor Diesel developing 200 b.hp. at 225 r.p.m., has carried out an interesting series of propeller experiments. Starting out with a built wheel in which the pitch of the blades could be altered, the Young Co. used a number of cast steel wheels of nearly the same diameter and pitch, but with slightly varying areas and changes in the shape of the blades. Most of these wheels would have satisfied the average towing man, but the Young Co. did not rest content till they had a wheel that met their log towing requirements and apparently could not be appreciably improved on.

SEA WAVE is a heavily constructed craft with sawn fir frames, and planked with fir. She measures 85 ft. overall by 19 ft. beam and has a draft of 9 ft. 8 in. Her first propeller of 76 in. diameter and 42 in. pitch (when adjusted for towing) was a 4-blade wheel having a projected area of 15 sq. ft. This proved too heavy for efficient log towing, only turning up 207 r.p.m. while the engine was rated to develop its power at 225 r.p.m. Another wheel was tried with three blades having 76-in. diameter and 40-in. pitch with 13½-ft. projected area. This was a fine towing wheel turning up 225 r.p.m. with logs, though if opened up running light the engine would speed it up to 289 r.p.m. However, it was found to have rather a poor grip going astern, so yet another wheel was ordered of three blade type having the same diameter and pitch but 14 ft. projected area, which held the engine down to 216 r.p.m. on a heavy tow. The next wheel which also had three blades and kept to the 76 in. diameter and 40 in. pitch was shaped slightly differently and turned up 122 r.p.m. towing logs. It was then decided that this wheel was good enough to go ahead and have a bronze one made with some very slight modifications in shape. This bronze wheel is a 3-blade propeller with 76 in. diameter and 40 in. pitch and is a Coolidge Pacific type of towing wheel, the leading edge of the blades being amost straight, and the tips comparatively wide. It turns up 222 r.p.m. normally towing 24 sections of logs, and is capable of turning up to 235 r.p.m. on an overload. When the tug is traveling light, the engine is run at 250 r.p.m., or 25 r.p.m. above the normal at which it develops its rated power. T. Halliday and the Wallace Shipyards at Vancouver and Coolidge of Seattle all had a hand in designing wheels for the SEA WAVE so that the owners made good use of some of the best designing talent on the coast, besides their own experience, in getting the best wheel for log towing.

Mr. Gore who is the engineering expert of the company has made some alterations to the controls of this Diesel which have materially improved it for tugboat work. The controls have all been carried to the upper platform of the engine room where the engineer can see how much power is required for any particular maneuver, and where reversing previously required six different actions with the hands, this has been reduced to two, while the shifting of the cam shaft is done with the knees, a suitable lever is being provided at just the right height. Mr. Gore says that he now reverses the engine in 2 sec., except when the boat has full headway.

Blue Band Navigation Co. of Vancouver has also had an interesting experience with towing wheels. They converted the steam tug PROSPERATIVE 30 ft. overall by 20 ft. 6 in. beam, installing a 6-cylinder Winton Diesel developing 225 b.hp. at 250 r.p.m. The first propeller was a 4-blade cast steel wheel of 78-in. diameter and 48-in. pitch which only turned up 230 r.p.m. towing 24 sections of logs. Another wheel with four blades having 78-in. diameter and 47-in. pitch and normal area was tried out, but did not suit, so a third wheel was cast with three blades having 69-in. diameter 42-in. pitch and 11.32-ft. projected area. This is used with successful results turning up to 250 r.p.m. towing logs. The PROSPERATIVE has been well tested on heavy towing. In one period of three weeks she brought in three 24 section booms, averaging close to 1,000,000 ft. board measure each, two being from Deep Bay, Vancouver Island, across the Strait of Georgia to Vancouver, B. C. The distance is about 80 nautical miles, a steady pull of 72 hr. unless the tug is forced to break the trip to find shelter from bad weather.

The Blue Band Co. later converted another steam tug, the PROSPECTIVE No. 2, in June, 1925. This tug of 87 ft. overall by 18-ft. beam was equipped with a 6-cylinder direct reversing Fairbanks, Morse Diesel engine developing 360 hp. at 250 r.p.m. in place of a compound steam engine of 160 i.hp. In this case they have another satisfactory wheel, a 4-blade cast iron propeller of 72-in. diameter and 46-in. pitch with 12-ft. projected area being cast especially by the Wallace Shipyards. This wheel turns up 252 r.p.m. normally when towing logs, according to the chief engineer; and if an extra pull is required will turn up as high as 262 r.p.m. Running light the tug makes 9 knots, the engine turning up 250 r.p.m., but if the throttle is opened up it will turn 270 r.p.m. or higher. PROSPECTIVE No. 2 normally tows 36 sections of logs.

The most powerful Diesel tug at present operating on the British Columbia coast is the NORSHORE, formerly the Dutch tug LUCIENNE, which is owned by the Pacific Coyle Navigation Co. She is a steel craft, 87 ft. overall by 19 ft. 8 in. beam and 10-ft. draft and is equipped with a Sulzer Diesel developing 420 b.hp. at 200 r.p.m. This tug came out from Holland under her own power via Panama, and when first used for towing on this coast used a 4-blade wheel of 78-in. diameter and 69-in. pitch, which was useful for towing ships and barges, but very unsatisfactory with heavy log booms, only turning up about 160 r.p.m., it is said. Her new wheel of 78-in. diameter by 51-in. pitch is reported giving good service towing logs at 195 r.p.m. She handles a tow of about 40 sections.

A number of other oil engined tugs are also engaged in log towing.

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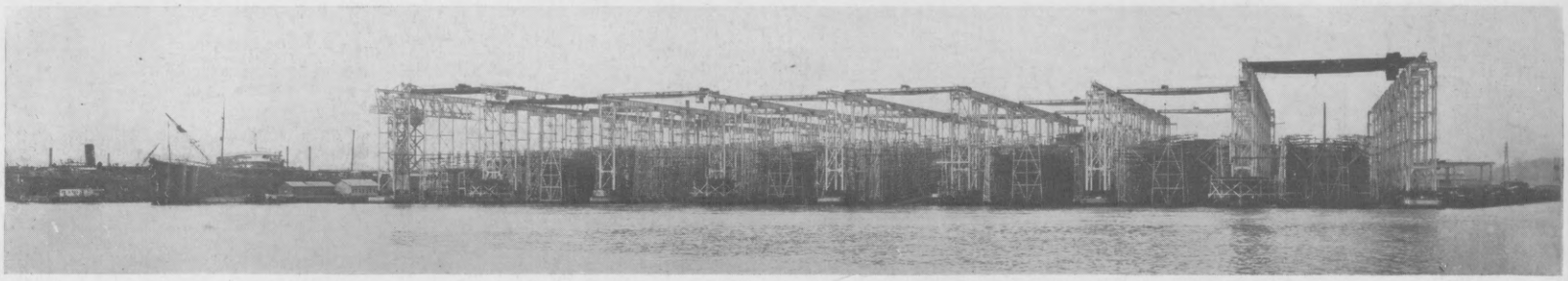


Sun Shipyard Building Many Diesel Craft

Work Commenced on 15,000 Ton Diesel Tanker and on a 13,000 Tonner—Tank Barges Also Fitting Out and Building

THERE is an agreeable burst of activity in motorship construction now going on at the plant of the Sun S. B. & D. D. Co., Chester, Pa., where two large tankers of over 10,000 tons capacity are building, both of which are to be fitted with Sun-Doxford Diesels; one is a 13,300 ton ship to have 3000 s.hp. engines, and the other a 15,000 ton capacity ship to have 4000 s.hp. engines. In addition to this there are several shoal draft and coastwise oil barges fitting out, designed especially for carrying refined oils, coastwise or in estuaries. The table above gives some general particulars of these ships, while on the opposite page is illustrated the barge SUNOCO, which, although now completed and in service, is of sufficient importance to warrant mention here.

SUNOCO is a remarkable vessel in many ways. She has practically no superstructure, and this will, if necessary, enable her to navigate the State Barge Canal and go on up to the Great Lakes. Her wheelhouse is of sunken type accordingly. In the few months in which she has been in active service, however, she has made several long distance voyages coastwise and is reported to be an excellent sea boat. She has taken cargoes from Philadelphia to New York, Philadelphia to Boston, Philadelphia to Providence, Philadelphia to Baltimore, and has been worked very hard since her owners took her from the shipyard. She is powered by two 8-cylinder Bessemer Diesels which develop 360 h.p each at 277 r.p.m. The auxiliary machinery is all electric and current for this purpose is supplied by two 50 kw. generator sets each driven by a 4-cylinder, 80 hp. Bessemer Diesel. The two cargo oil pumps are each driven by 50 hp. Diehl motors through De Laval reduction gearing. The motors themselves are in the engineroom and the pumps in the pumproom forward of the engineroom.

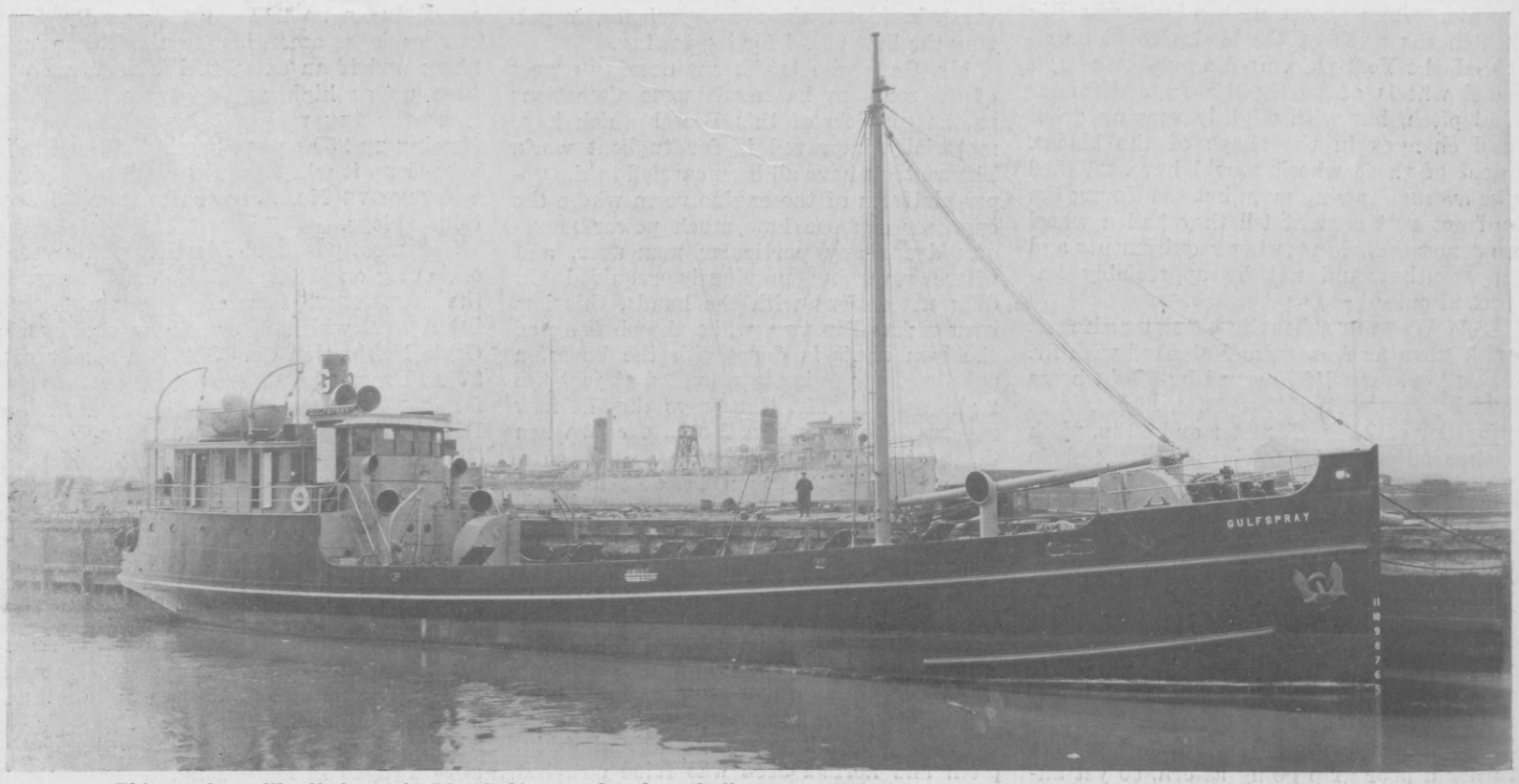
Ms. GULFSPRAY and GULFSPRITE, built for the Gulf Refining Company, whilst fulfilling basically the full role, have somewhat different arrangement. The pilot house and accommodation is all arranged aft in a poophouse. There is also a short mast with a derrick taking care of cargo from a small cargo hold forward. This hold, it is gratifying to notice, has a steel hatch cover, a point of some value to a ship which will probably be plugging into head seas.

Ms. TYDOL, which is now approaching the launching state will be similar in many respects to the SUNOCO described above. Sun Shipyard is probably one of the best equipped yards in the country, and in addition to its extensive repair department has eight building berths with overhead gantry cranes, capable of taking vessels up to about 600 ft. in length.

There is also an extensive ship repair department with docks.

Recent Diesel Tank Barges Built at Chester

NAME	LENGTH B.P.	BEAM MLD.	DEPTH MLD.	CAPACITY
Sunoco	245.5	40.0	15.0	650,000 gal.
Gulfspray	136.0	27.0	11.5	142,000 gal.
Gulfsprite	136.0	27.0	11.5	142,000 gal.
Tydol	252.0	40.0	14.0	742,500 gal.



This workmanlike little craft, Ms. Gulfspray, has been built to carry 142,000 *gal. of refined oil coastwise in southern waters*

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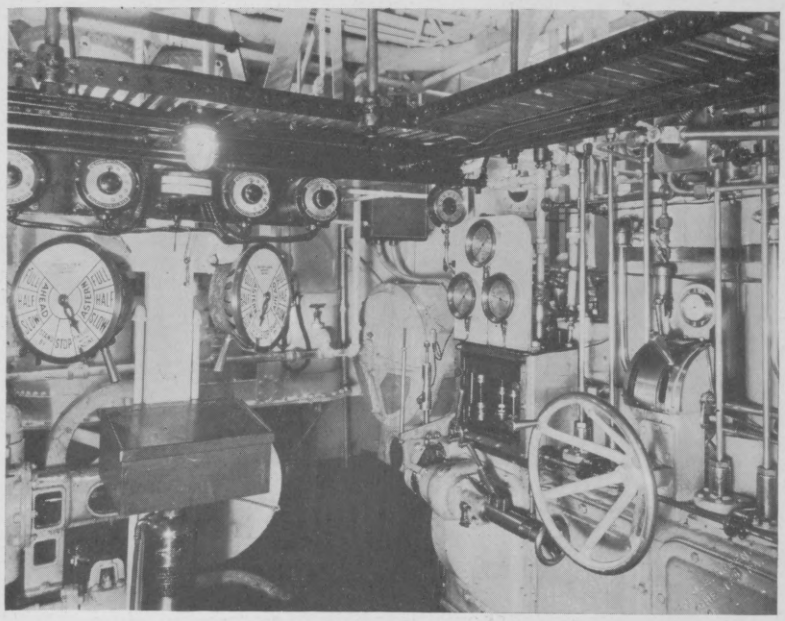
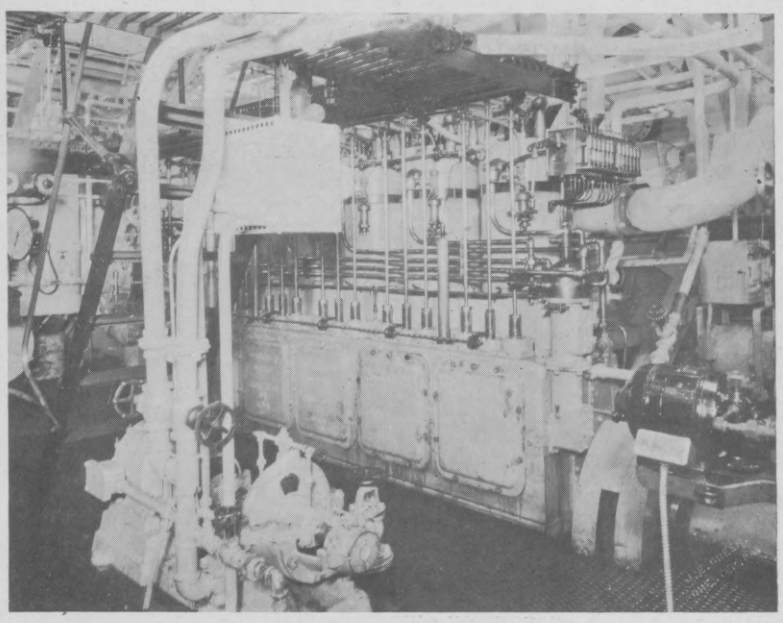


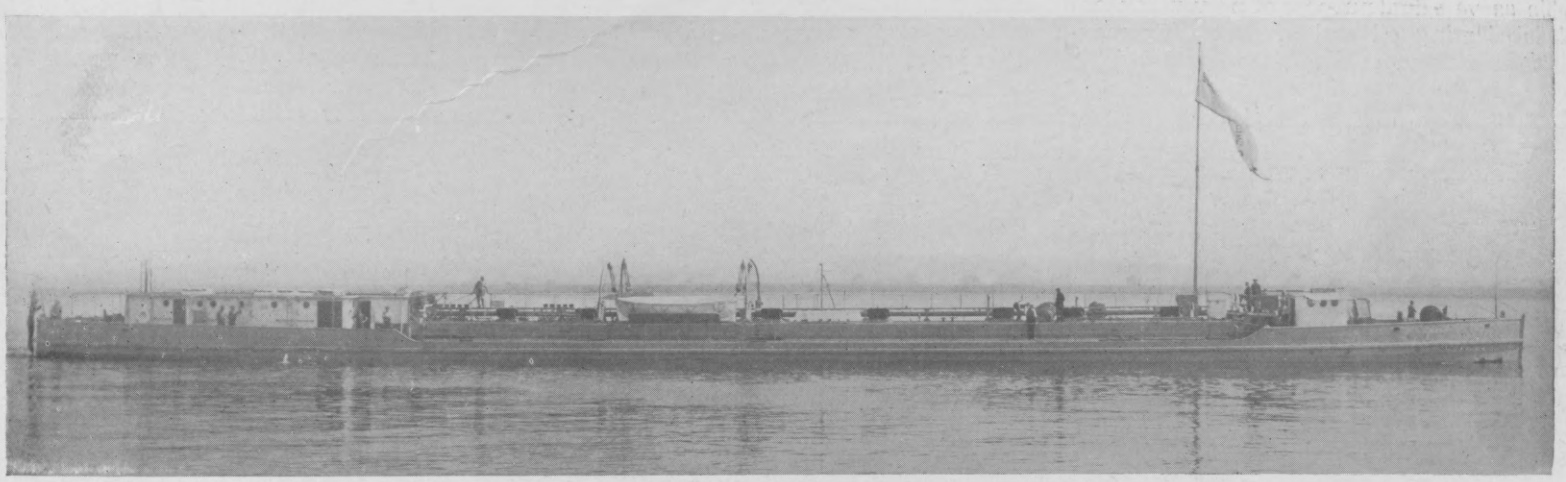
Control position between engines



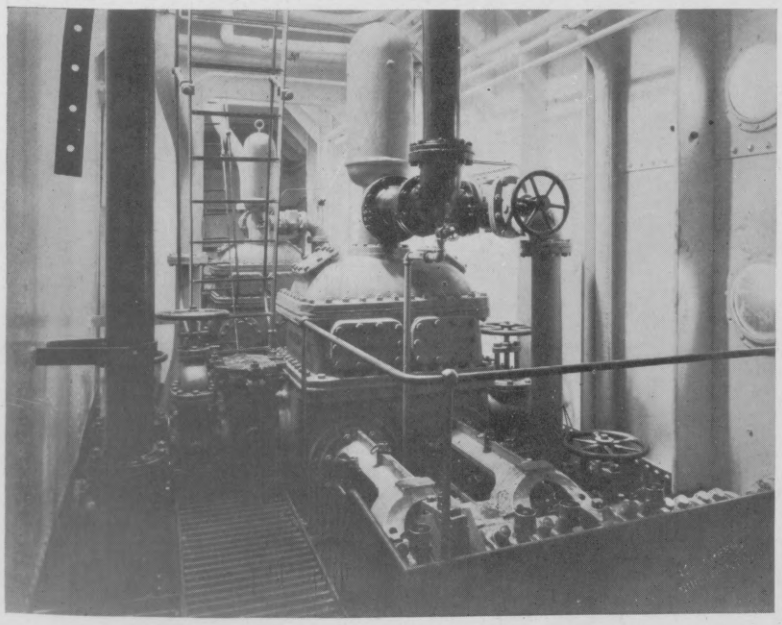
One of the main 360 hp. Diesels

The Big Diesel Driven Tank Barge Sunoco

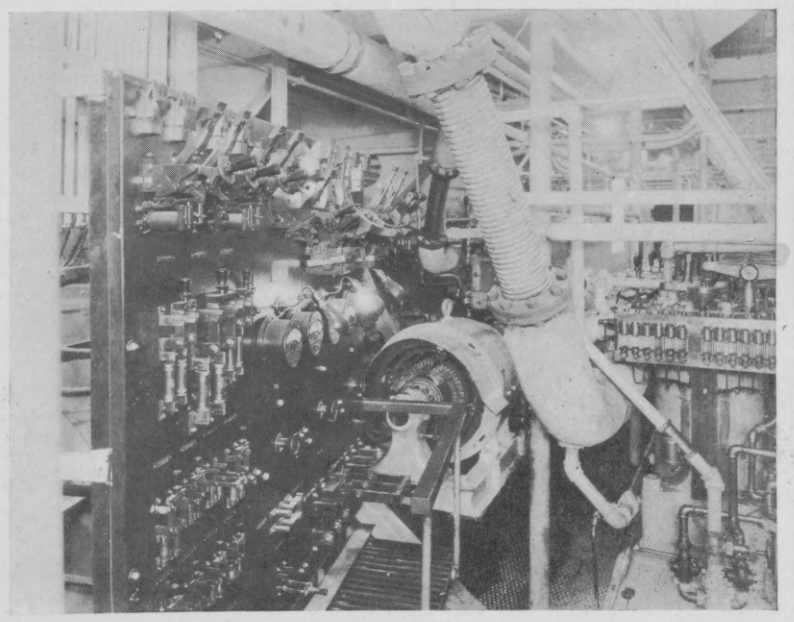
Has a Total Capacity of 650,000 Gal. and 720 Hp. Diesel Power on Two Shafts



Shows the tank barge Sunoco loaded with a capacity cargo. Her low upper structure makes her suitable for canal work



Pump room forward of engine



Main switchboard

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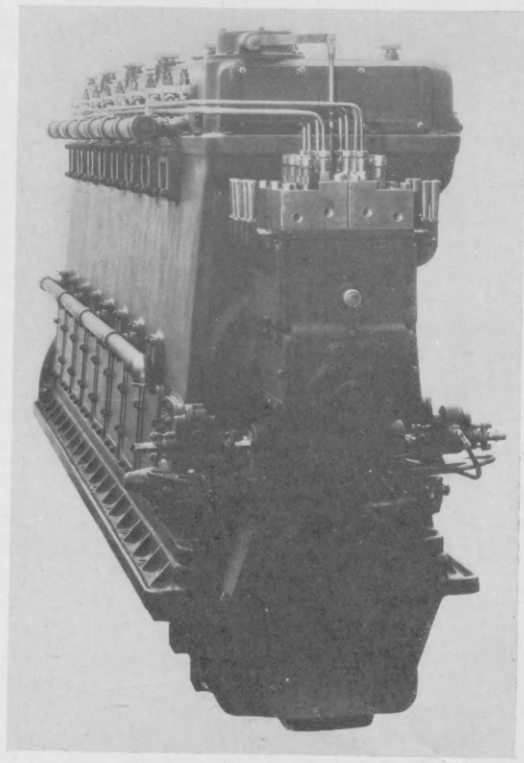
Lightweight Diesel with Big Power Range

Latest Foos Type L Engine Available in Powers from 50 to 375 Hp. Incorporates Simplicity in Design and Operation

A LIGHTWEIGHT medium high speed Diesel recently completed by the Foos Gas Engine Co., Springfield, Ohio, for marine work and designated the Foos Type L Diesel Engine incorporates in its design and construction important features adding to economy and simplicity of operation and to the operating life of the engine. The new features are the result of 40 years' experience in the design and construction of internal combustion engines. The new engine is of the 4-cycle type, using the airless injection fuel system, which latter is accomplished by small individual pumps, one for each cylinder, inter-connected with the governing mechanism. This arrangement prohibits the overloading of any one cylinder.

The unit is lubricated by a fully automatic circulatory system, even to the valves, valve gear, rocker arms and rollers. The lubricant is picked up from the base by a pump driven from the cam shaft and placed under pressure and distributed to every moving part. Not a single oil or grease cup is to be found in the engine.

To serve a dual purpose of preventing loss of lubricating oil and of protecting moving parts from coming into contact with foreign matter the engine is completely enclosed. This is a step in Diesel engine practice. All moving parts are fully enclosed with the exception of the main driving shaft, even the fly-wheel being enclosed.

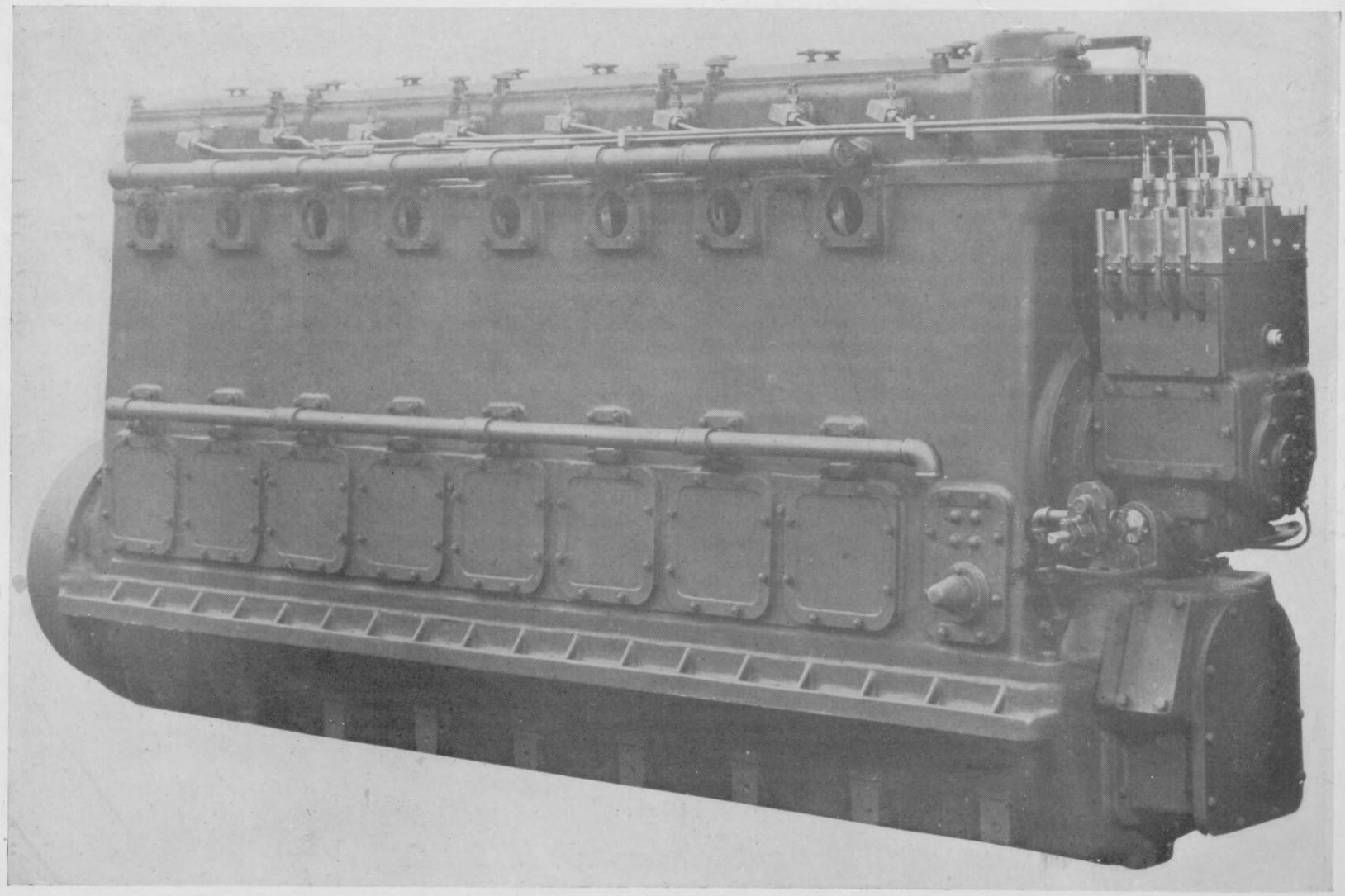


End view of Type L Engine

While fully enclosed the engine is yet readily accessible, since large cover plates are provided on both sides opposite the crank throws which give access to the lower part of the main cylinder frame, bearings, etc. The top of the engine is provided with cover plates for inspection of the head, valves, and valve mechanism.

Physical characteristics of the new unit show a low height, narrow width, and small length of the complete unit. This permits its installation on yachts, and on small craft where space is necessarily limited.

The Foos Diesel operates on the full Diesel combustion cycle. A cross section of the engine indicates a plain combustion chamber, the head being perfectly flat, there being no recesses or precombustion cups of any type. Injection of the fuel is vertical, at the axis of the cylinder. Complete atomization of this fuel, causing a low fuel consumption with clear exhaust, is secured by the Foos mechanical injection principle.



Foos Type L Diesel shows a rugged and workmanlike outline characterized by simplicity

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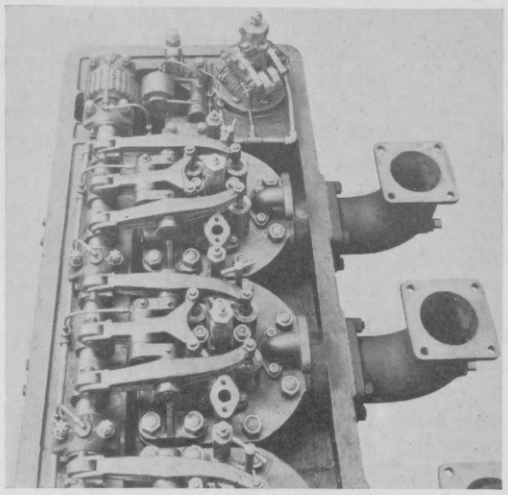
The dual valve system is provided,—two inlet and two exhaust valves being fitted. The use of two valves provides maximum oxygen for good combustion and results in a very neat arrangement, with shorter lifts, lighter springs and less wear on cams. At the level of the head of the main frame which houses the entire unit, a recess in the casting provides the air inlet manifold, consequently the air inlet valves are located in the head adjacent to the front side of the engine.

Passage through the main frame at the back of the engine is provided for the exhaust gases to enter the exhaust header. Valve operation is controlled by a camshaft running the full length of the engine at the level of the cylinder head, the camshaft being driven by a silent chain direct drive from the crankshaft. The whole valve and head arrangement is very simple and accessible, it being so arranged that any of the valves or valve levers proper may be removed without disturbing any other part of the mechanism.

Pressure lubrication has the dual purpose of supplying lubricant and carrying away heat. In an oil engine operating with speeds as high as 900 r.p.m. the subject of bearings is an important one. In the Foos Type L the bearing beds or bases are bored with their caps in position, shims being interposed.

Babbitt is then poured against the tinned surfaces of the bronze back shells. An important feature with these shells is that of substitution of uppers for lowers by the simple process of lifting out the hollow dowel in the cap and rolling the lower out and the upper in. Care must be taken not to impose too heavy a load on the upper shell thus "rolled" under. The real value of this arrangement permits the installation of new bearings should the occasion arise.

The cylinder liners are held in the upper base by an integral flange or collar, with rubber gaskets above and below to prevent water leakage. The liner takes explosive pressure and rod and piston thrust



View of cylinder tops

and although of thin section readily to transfer heat, it has all the strength necessary to withstand the high internal pressures.

The piston is cast iron, lubricated by the mist from revolving parts, there being no reservoirs or oil cups to fill. The piston pin is hollow and lubricated by a steel tube fixed in the connecting rod and fed from the main circulatory system. The upper end of the piston is concave.

The engine proper consists of two major castings, the upper half carrying cylinder liners, heads, etc., while the lower part houses the crankshaft and main bearings. Two longitudinal flanges run the full length of the lower half and serve to support the engine.

The camshaft is provided with two sets of cams, ahead and astern, for direct reversing. The shaft is operated laterally by air. For direct reversing in the smaller sizes a marine type reverse gear is used. When desired, the unit can be arranged for opposite rotation in twin screw vessels.

The engine is flexible and easily controlled, all controls, etc., being located at the governor end of the unit. For marine maneuvering a manual speed control is provided as the engine can be made to throttle down to a very low speed and pick up to full speed without jerking or slipping, in much the same manner as the automobile engine. However, when it is necessary to operate the engine at a reduced speed for any length of time it is advisable to set the governor.

The Foos Type L Diesel is built in sizes of two to eight cylinders with a bore of 8½ in. and stroke of 11 in., the speed ranges being from 300 r.p.m. to 900 r.p.m. giving a power rating of 50 to 475 b.hp. based on 70 m.i.p. Engine weight complete averages from 60 to 30 lb. per hp. depending on the horsepower and speed.

A 200 hp. Foos Diesel can be placed in the same approximate space requirements as heretofore required by an engine of 75 to 100 horsepower.

Southern Pacific's Diesel Ferries Ready

Big Diesel-Electric Ferryboat Fleet Containing 24 Main Engines Now Fitting Out for San Francisco Service

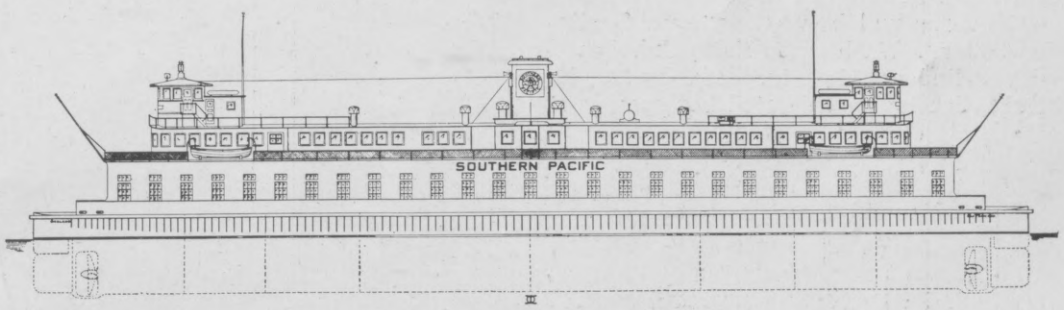
FRESNO, one of the four Diesel-electric ferryboats under construction for the Southern Pacific Railroad, was recently launched and machinery is now being installed. STOCKTON, another of the four, is nearly ready for launching and installation of machinery, while TAHOE will probably be the third to go into service. All three are being built by the Bethlehem Shipbuilding Company of San Francisco. The fourth boat is being built by the General Engineering & Drydock Company.

Southern Pacific Railroad, owners of a large number of steam engine driven boats, including one of the largest ferries in the world, has up to this time had no experience with electric drive. Its decision to build the new boats followed closely on the heels of the building of three Diesel-electric ferries for the Golden Gate Ferry Company and the service of the Diesel-electric tankers owned by the Standard Oil Company of California.

All the boats are expected to be in service by spring or early summer. They will be operated in San Francisco Bay.

They will be of the double-ended type, equipped with pilot house control, and will be used principally in vehicular service, although accommodations for a number of passengers will be carried.

The boats will be completely electrified with General Electric equipment. The main generating plant on each will consist of four main Diesel engines built by the



Six Diesel ferries of this type are completing for Southern Pacific Lines

New London Ship and Engine Building Company of Groton, Conn. Each engine will be rated 450 b.hp. at 230 r.p.m., and will be direct connected to a 275-kilowatt, 250-volt, direct-current generator for supplying power to the propulsion motors, and a 40-kw. 125-volt, direct-current auxiliary generator. The auxiliary generator will not only supply excitation to the main generator and motors but will also furnish power for lights, ventilation and auxiliary equipment.

There will be two main propulsion motors on each boat, one at each end and each rated 1250 s.hp. at 130 r.p.m. These motors will be so arranged that the speed of either may be varied over a wide range, thereby dividing the load between the bow and the stern motors at the will of the operator. The variable voltage system of control will be used, for operation either from pilot house or engine room.

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Big Diesel Ferry for Columbia River

Union Pacific Co. Constructing End Loading Ferryboat for Columbia River Service as Link in New Highway System

ENTERING the automobile and passenger ferry service across the Columbia River from Astoria, Ore., to Megler, Wash., the southern terminus of its Ilwaco and Nahcotta railway line, the Union Pacific System is constructing a wooden ferry which will be the largest and most modern craft of its type on the Columbia or Willamette rivers. The new boat will be 115 ft. in length, with a beam of 37 ft. and will accommodate 35 automobiles and 250 passengers. The veteran river steamer NAHCOTTA, which has maintained the run between Astoria and Megler for many years, will be retired with the commissioning of the new craft, which was designed under the direction of S. Murray, assistant chief engineer of the Union Pacific System. The new ship is end loading at both ends and, while in general outline resembling the true double ended type, is actually only single ended with a single propeller at one end.

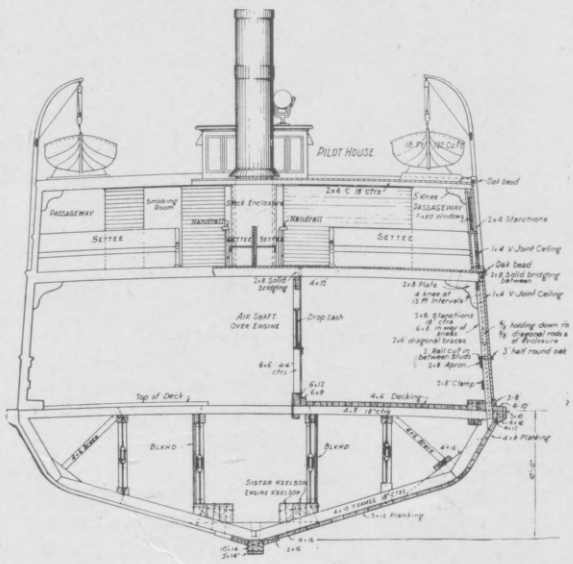
In adding automobile transportation to its passenger and freight business, the Union Pacific System has been put to the necessity of constructing a road from Megler West to the end of the present highway at Point Ellice. This road is now under contract and will be completed by the time the new ferry goes into service in the spring.

The new ferry will connect with the Union Pacific trains on the Washington side of the Columbia River, thus giving rail and highway connection with Fort Columbia, Chinook, McGowan, Ilwaco, Fort Canby, North Head, Seaview, Long Beach, Breakers, Ocean Park, Oysterville, Nahcotta and a loop trip by road over the Ocean Beach highway in Washington through South Bend and Raymond to the Pacific Highway at Chehalis.

The ferry is being constructed at the plant of the Peninsula Shipbuilding Company in Portland. She has the following dimensions:—length o.a., 115 ft; beam molded 37 ft; depth molded 10 ft. and draft, 6.25 ft.

The ferry will be powered by a 6-cylinder 300 hp. Washington-Estep full Diesel with cylinders 11½ in. bore by 16 in. stroke, developing its rated horsepower at 280 r.p.m. The engine is direct reversible. The complete installation is being carried on under the supervision of the Washington Iron Works of Seattle, manufacturers of the Washington-Estep Diesel engine.

The main auxiliary engine will be a 12 hp. Viking oil engine with compressor and generator mounted on the same base. A



Midship section of new ferry

clutch will be provided to permit the operation of either or both of these units. A high pressure water pump will be installed adjacent to the auxiliary engine and will be driven by a silent chain operating through a clutch.

A slate switch panel will be installed at a convenient point for operation of power and light circuits. For emergency use a small generator for lighting purposes will be driven off the main engine. The steering engine will be air actuated with lever control in the pilot house. There is in addition a hand steering wheel for standby.

The automobile deck will be entirely enclosed save at the ends, thus protecting automobiles carried from spray and weather. It will be clear except for a 7 ft. strip amidships and running half the length of the craft in which will be located the stairs to the passenger deck and the upper portion of the engine room. This deck will be fitted with a turn table for the manipulation of the automobiles if desired. The car deck, however, will be open at both ends, permitting motorcars to enter and leave in either direction.

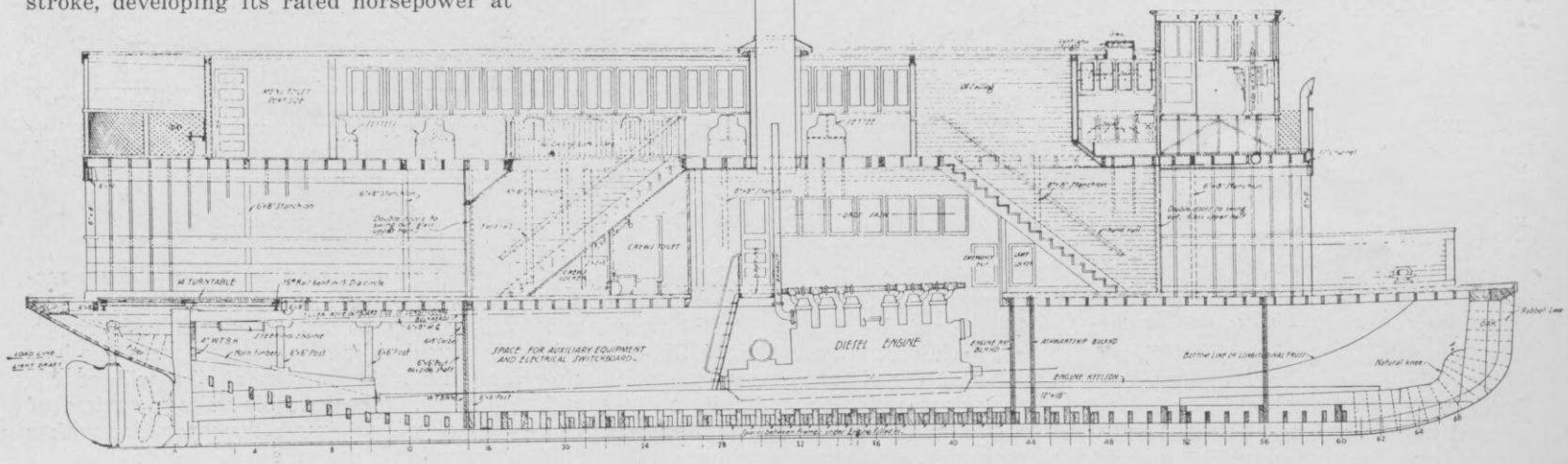
The passenger cabin above the auto deck will accommodate 250 persons. It will be fitted with settees. There is a smoking room on the port side of this deck, with a lunch room opposite. Well-equipped toilet rooms are located at the after end of the cabin and at either end of the house is an open deck space.

The ferry will be very strong structurally with 12 in. by 18 in. firm timbers for engine and sister keelsons. The auxiliary engine equipment will all be located aft of the main engine room, with two 500 gal. fuel oil tanks forward. The hull design calls for four athwartships bulkheads.

Four longitudinal trusses run the full length of the hull. The inboard trusses will be spliced into the sister keelson at all points where the lower chord meets the sister keelson. This lower chord will be shaped from 12 in. by 12 in. stock, while the upper chord will be 8 in. by 10 in. Diagonals are 4 in. by 4 in. and all tie rods are 1¼ in. steel. Dimensions in both the inboard and outboard trusses are on 5 ft. centers.

Planking from the main deck to the knuckle of the hull is 4 in. by 8 in. fir while the bottom planking is 3 in. by 13 in. stock. The automobile deck is made up of 4 in. by 6 in. planking. Frames are 4 in. by 10 in. on 18 in. centers with all frames under the engine timbered in solidly. The interior of the bow is built up solidly with oak around a natural knee.

Union Pacific's program calls for completion of the ferry so she can be put into service in time for the annual tourist trade. In addition to the construction of the connecting road from Megler to Point Ellice, the company is building a ferry slip in its dock at Megler and at Astoria.



Inboard profile of new Diesel ferry for Union Pacific system which will have a propeller at one end

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Sea-Going Hopper Dredge "Willets Point"

Discussion on Novel Features Incorporated in New Vessel's Design and Construction Continued from the February Issue of Motorship

By Northrop R. Fletcher*

ANOTHER feature that should make the boat sensitive to her helm is the shape of the stern. The hull runs up very full from the flat keel about 28 ft. forward of the transom to the stern bulwark plate. Extending aft 22 ft. from the rise of keel knuckle is a flat skeg 8 in. wide, built of plates and channels and filled with creosoted wood. The lower edge of this skeg forms a continuation of the base line.

It will be noted that the metacentric heights are rather large for both loaded and light conditions. This fact is, of course, a natural result of the limitations of the design of the hull as discussed above and of the weights of the engines and the dredge pumps which are rather low in the hull. The hull should be rather stiff in rolling. This great stability will be reassuring when the dredge dumps at sea, particularly in view of the fact that the freeboard will be only 3 ft. when she is loaded. Ordinarily the dredge turns as she dumps. If the sea is heavy the pockets should be clear before she is caught in the trough, but often the mud sticks in one side or the other. In the empty bins there is a large free water surface. Consequently a large factor of safety in stability under all conditions of loading is desirable.

For propulsion, two 8-cylinder Winton Diesels are used, direct connected to propellers. These engines are rated at 450 H. P. at 250 r. p. m.

The stern tube bearings are of the "Cutless" type manufactured by the B. F. Goodrich Rubber Co. In operation, mud, sand, and other gritty material stirred up by the drag and discharged by the overflow troughs remains in suspension in the water surrounding the dredge. It has been found impossible to keep this grit out of the stern tubes and strut bearings. As a matter of fact, the water service to the bearings is often gritty. As a result, the conventional types of stern tube bearings are cut out in a very short time. It is expected that the "Cutless" bearings will last longer under these conditions. As an additional precaution against trouble, the shafts between the stern tubes and the struts have been covered with stationary, watertight steel sleeves.

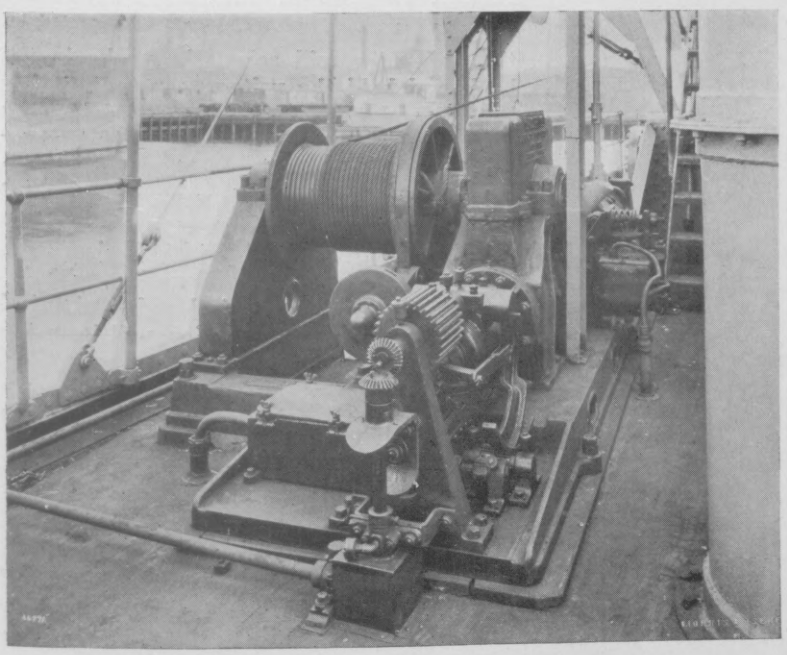
Three Diesel driven generators have been installed. An 8-cylinder engine, similar to the propelling engines, was rebuilt by the manufacturers and direct connected to a 325 kw., 230 volt, d. c. Westinghouse generator. This generator will furnish power to drive the dredge pumps, and for auxiliary purposes. For further auxiliary power a 4-cylinder, Winton-Diesel, direct connected to a 65 kw., 230 volt Westinghouse generator is installed, while a 3-cylinder Hill-Diesel driving a 12 kw. General Electric generator will furnish power for lighting and light auxiliary load when the dredge is lying at dock. A 110 volt Edison storage battery is also provided for lighting when all generators are shut down. Provision is also made for supplying power from shore to the main switchboard through a junction box on the main deck.

To facilitate maneuvering while dredging, speed control wheels have been installed in the pilot house. These controls are mechanically connected to the governor controls on the propelling engines. It is not the intention to operate the engines from the pilot house. The engineer will have to stand by at all times at the starting platform, but the fine increments of speed on each wheel, necessary to hold the dredge on its course at low speed, can be obtained directly without the introduction of a second human factor. Such a control has been used successfully on steam dredges.

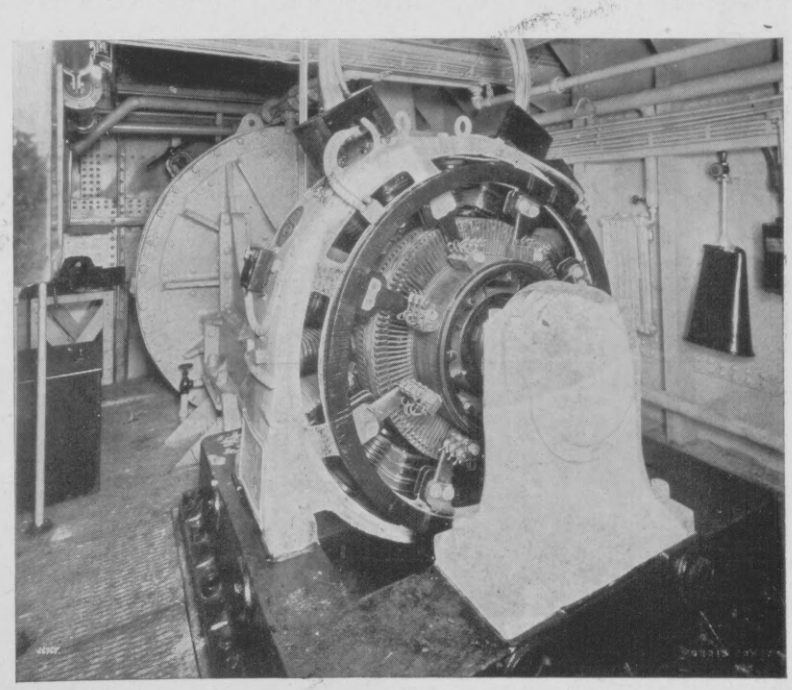
The engine room is aft of the hopper space. Forward of the hopper space, in a compartment running the full width of the dredge, are the two dredge pumps. These are centrifugal units with single suctions and closed impellers of the backward discharge type such as are common for this service. The impellers are 4 ft. 9 in. diameter with five vanes. The hubs of the impellers are not bored for a tapered shaft as is ordinarily done, but are threaded to fit an acme thread on the end of the shaft 7.437 in. diameter by 1 in. pitch. In this way no shaft or nut extends through the front face of the back shroud. Water entering the throat of the impeller impinges on a smooth surface. In more conventional construction the impeller is held on a tapered shaft by a large nut directly in the suction of the impeller. When it was found necessary to remove such impellers the nut was usually worn smooth by the abrasion of the material handled by the pump and the tapered shaft was often corroded fast in the bore.

The pump shafts used in this installation are of forged carbon steel. The spring bearing pedestals for these shafts are fitted with S. K. F. roller bearings for radial load and, with deep grooved ball bearings of the same make for thrust. The motor pedestals are also fitted with roller bearings. To counteract the tendency of the discharge pressure of the pumps to force grit through the clearance between the back shroud and

*Inspector U. S. Engineer Office, 1st New York District.



Self-adjusting winch for dredge arm



Main dredge pump and motor

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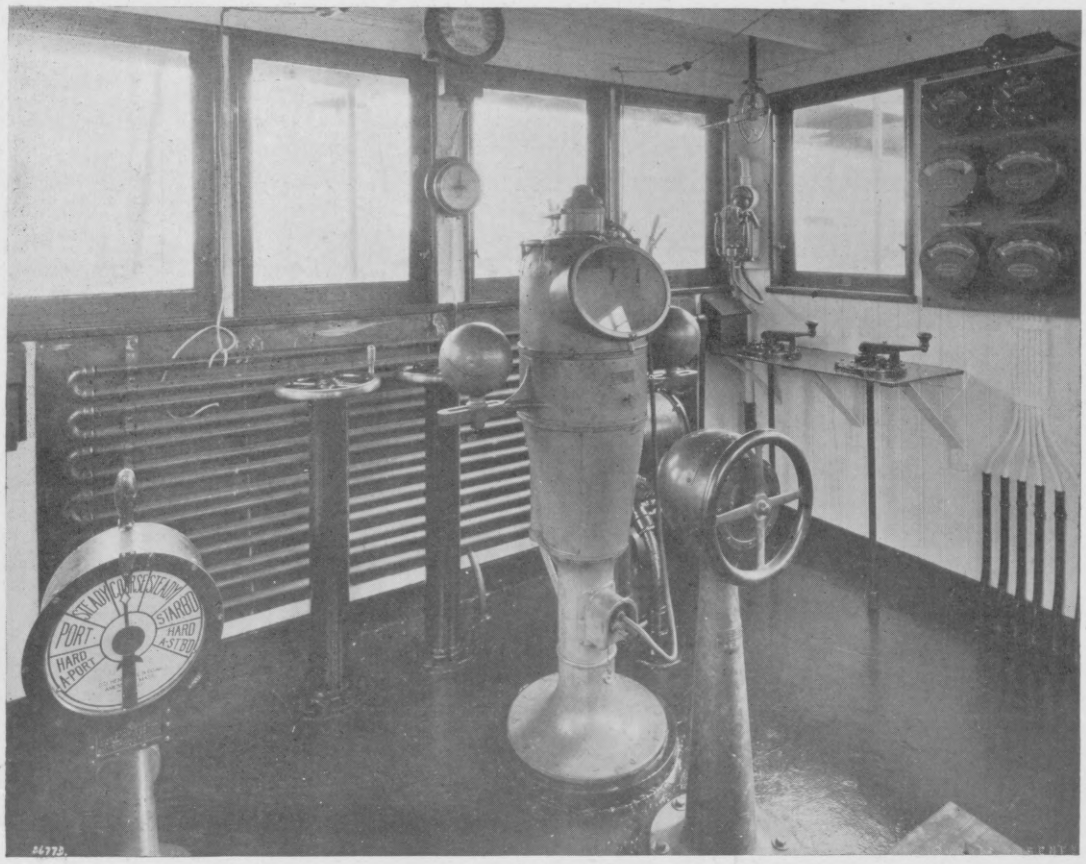
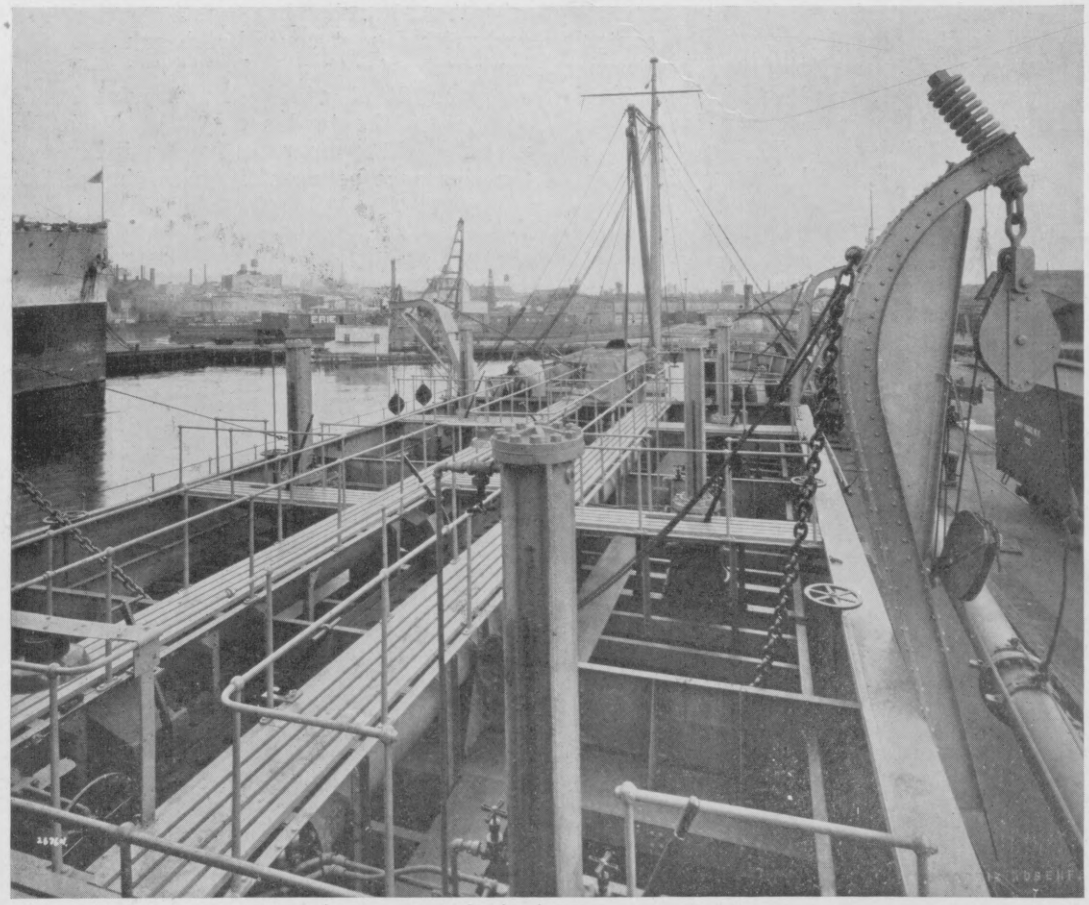


Wheelhouse of Dredge Willet's Point with engine controls

the casing to the shaft gland, clear water service is maintained inside of the glands by a small service pump. Even with this protection it has been found that the wear of dredge pump shafts in the glands is excessive. To protect the shafts, renewable sleeves are fitted that cover the shafts from the hubs of the impellers to the spring bearings.

As in other pumps for this service the clearances are large to prevent jamming of large rocks and trash, and the construction is heavy to withstand shock and abrasion. The pump casings are of cast steel completely lined on the inside with renewable liners. These castings have been made as simple as possible in order to facilitate assembly and the renewal of liners. The front and back heads are flat steel castings reinforced with radial ribs and with bracket pads on the back head for the support knees. A square volute section is formed by the flat heads and the volute castings. Three castings make a volute assembly in the form of an approximate cylinder of variable radius. The section of the volute is similar to that of a structural channel with the flanges on the outside bolted to the two flat heads. All the liners are made of flat structural steel plate with the exception of the conical throat liner which is of hard cast steel. The volute liner is bent with a single curve to fit the casing.



Looking over hopper tops of Dredge Willet's Point

These pumps are driven by 230 volt, compound wound, open type, d. c. motors, rated at 200 hp. each at 175 r. p. m. The starboard pump motor speed can be varied by field control to 225 r. p. m. The port pump motor can be run at 400 hp. at 325 r. p. m. for pumping ashore.

The characteristics of such electric motors have been found very satisfactory for power for dredge pumps. In operation, the load is never constant. Even in the most uniform digging the percentage of solid material and water passing through the pump varies rapidly. The suction and discharge pressure gages go up and down. The design of the pump runner helps smooth out this variation. When the effective pressure on a backward discharge impeller increases, the volume of discharge should decrease in such a ratio that the load on the shaft will tend to remain constant. Unfortunately this increase in pressure is usually accompanied by a rapid increase in the viscosity and fluid friction of the material in the pump. If the driving machinery can stand this momentary load without a material decrease in speed, the pump will soon free itself with the aid of intelligent operation of the drag. If the pump stalls, it will fill with solid material and it may be necessary to dismantle the pump to clean it out before it can be started again. Consequently this difference in the driving engine means a difference in the output of the pump in cubic yards of solid material. Directly the saving is obvious, indirectly a human element enters to an even greater degree. If the operator is afraid of choking his pump he will pump more water than is necessary to keep the mud fluid. This water is not only a direct loss in itself but it carries away a great amount of solid in suspension overboard through the overflow troughs. As long as the generator will carry the peaks in the load, and hold the voltage constant, it has been found that dredge pumps driven by compound wound motors of sufficient power can be maintained at a uniform speed. In this case power for both pumps is supplied by a single Diesel driven generator. Normally, an overload will not strike both motors at the same time. Together with inertia of the whole electrical and mechanical system this load distribution will keep the pump speed constant.

While dredging, both pumps will be run at the same speed, which will be from 150 r. p. m. to 200 r. p. m. In addition to the drag pipe suction, the port dredge pump is connected with a suction at the bottom of each hopper, and a discharge connection for a shore pipe. In pumping ashore, the discharge pressure will be much higher and the speed of the pump may be raised as high as to 325 r. p. m. to obtain this pressure.

(To be continued)

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Cummins Line of Small Diesel Engines

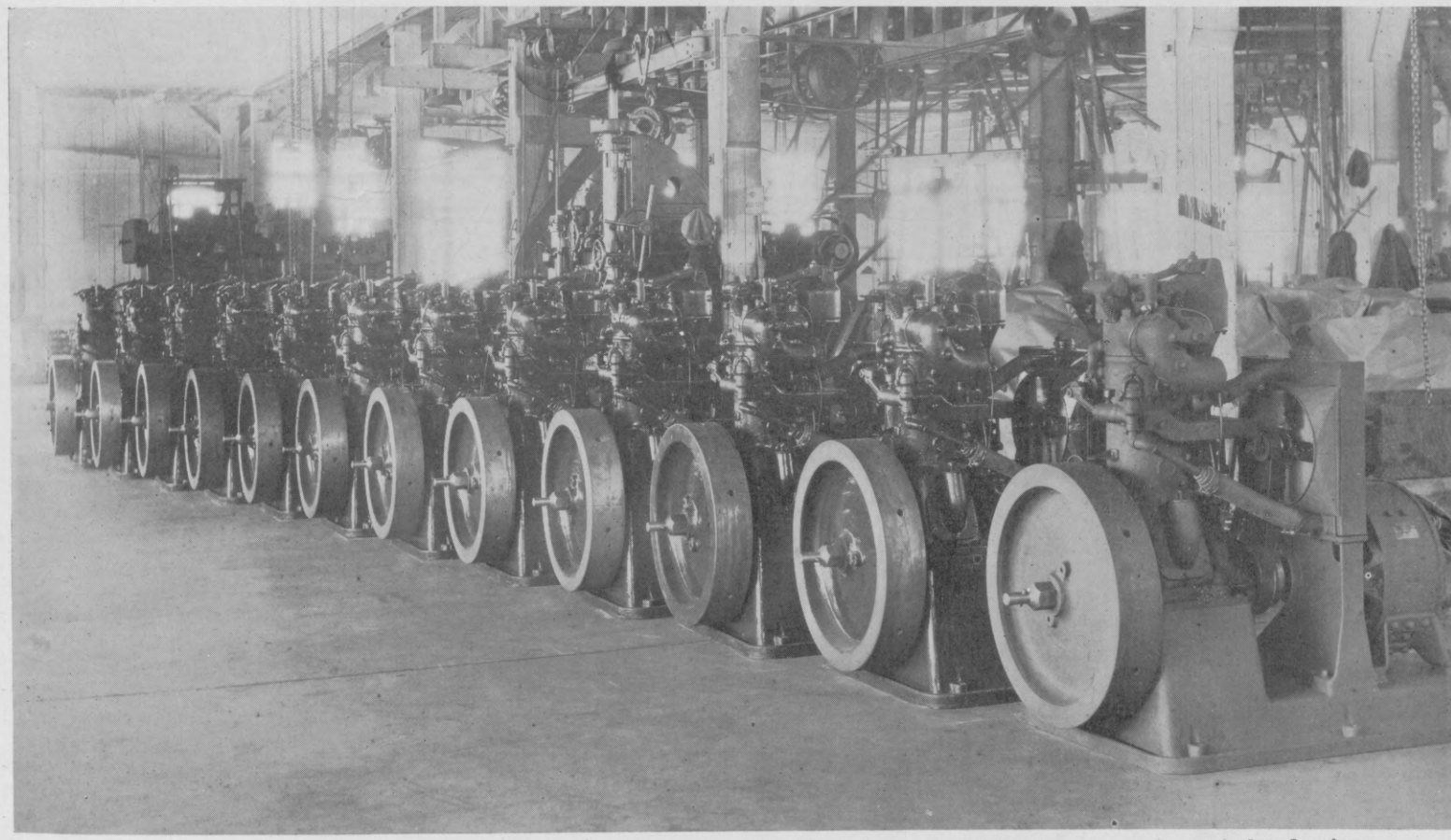
Standard Fuel Economy Secured by Simplified Fuel Injection System with Engine Speed of 600 r.p.m.

FUEL injection in the Cummins engines differs from ordinary airless injection in this respect that the fuel feeding pump operates at low pressure and the atomization of the fuel is accomplished by snapping the fuel needle. This arrangement simplifies the pump and the feed lines very considerably, minimizes adjustments in service, reduces maintenance and decreases the liability of derangements. It confines the high pressure fuel system to the fuel needle and nozzle, both of which are necessarily under pressure in any system of fuel injection.

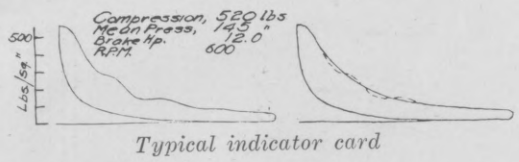
In other respects the Cummins engines conform to Diesel practice. The compression is about 520 lb. per sq. in. with little increase of pressure as the combustion starts, and the burning of the fuel at constant pressure shows quite clearly in the indicator cards. How this style of injection would suit larger and slower speed engines does not have to be discussed here. It works out exceedingly well in the Cummins engines with cylinders of 5½ in. bore and 7½ in. stroke, rated to deliver 12½ b.hp. at 600 r.p.m., and gives them a fuel economy always better than 0.5 lb. per b.hp.-hr. The consumption varies with the number of cylinders and with the grade of fuel. With a good fuel the 50 hp. 4-cylinder engine shows 0.45 lb. per b.hp.-hr. Any grade of fuel that will flow freely through the pipes can be burnt in these engines.

In small cylinders it is always permissible to operate at much higher mean pressures than are allowable in large cylinders. It is not surprising therefore to find the Cummins engines indicating mean pressures of 105 lb. per sq. in. or 110 lb. per sq. in. at full load. In shop trials much higher mean pressures have been indicated. An indicator card reproduced on this page shows a mean pressure of 145 lb. per sq. in.

Cummins engines have been going into service for the last three years, and a considerable number of them is now in use. There is nothing experimental about them. They have shown they can stand the gaff. They are built for small boats with reverse gears, and they are constructed also for direct connection with generators as auxiliary units on vessels of every type. The Bureau of Lighthouses has bought more than a dozen of the single-cylinder engines connected with a generator for service in lighthouses at isolated points.



Big batch of single cylinder Cummins Diesel engines ordered by the Bureau of Lighthouses for service at isolated points



Typical indicator card

In all details except the injection system the Cummins engines follow conventional practice. The inlet and exhaust valves are inclined in the cylinder head, but that is not unconventional although unusual. This method of locating the valves presents advantages in small engines and has been used before in other types of engine.

It is at once apparent from an examination of the fuel pump that its major function consists in maintaining a constant, steady head of oil on all the fuel valves of the cylinders, and that it takes no part in delivering the fuel to the actual engine cylinders. The spring-loaded cup-leathered plunger forms an effective substitute for the air-chamber usually found on the discharges of pumps.

In view of the fact that the pump is only of the low-pressure type extraordinary care seems to have been taken for insuring it against wear. The long ball-ended thrust rod for driving the hollow lapped plunger eliminates every trace of objectionable side thrust and should insure tightness over an indefinite period. It would seem as though the design is centered about maintaining the constant head on the fuel valves as the central consideration. The attainment of this object is no doubt assisted by the fact that the pressure is held only at such a figure—around 40 lb.—as is necessary to facilitate its accurate control. One pump serves for the entire cylinder group and the excess from each one not used by the fuel injector is returned to the pump by the drain tube already alluded to. A small spring-loaded ball check valve adapted to lift when the pressure tends to exceed its limit, is also fitted.

A common supply pipe provided with the necessary branches feeds all the fuel injectors, the essential construction of which is apparent from the cross-sections.

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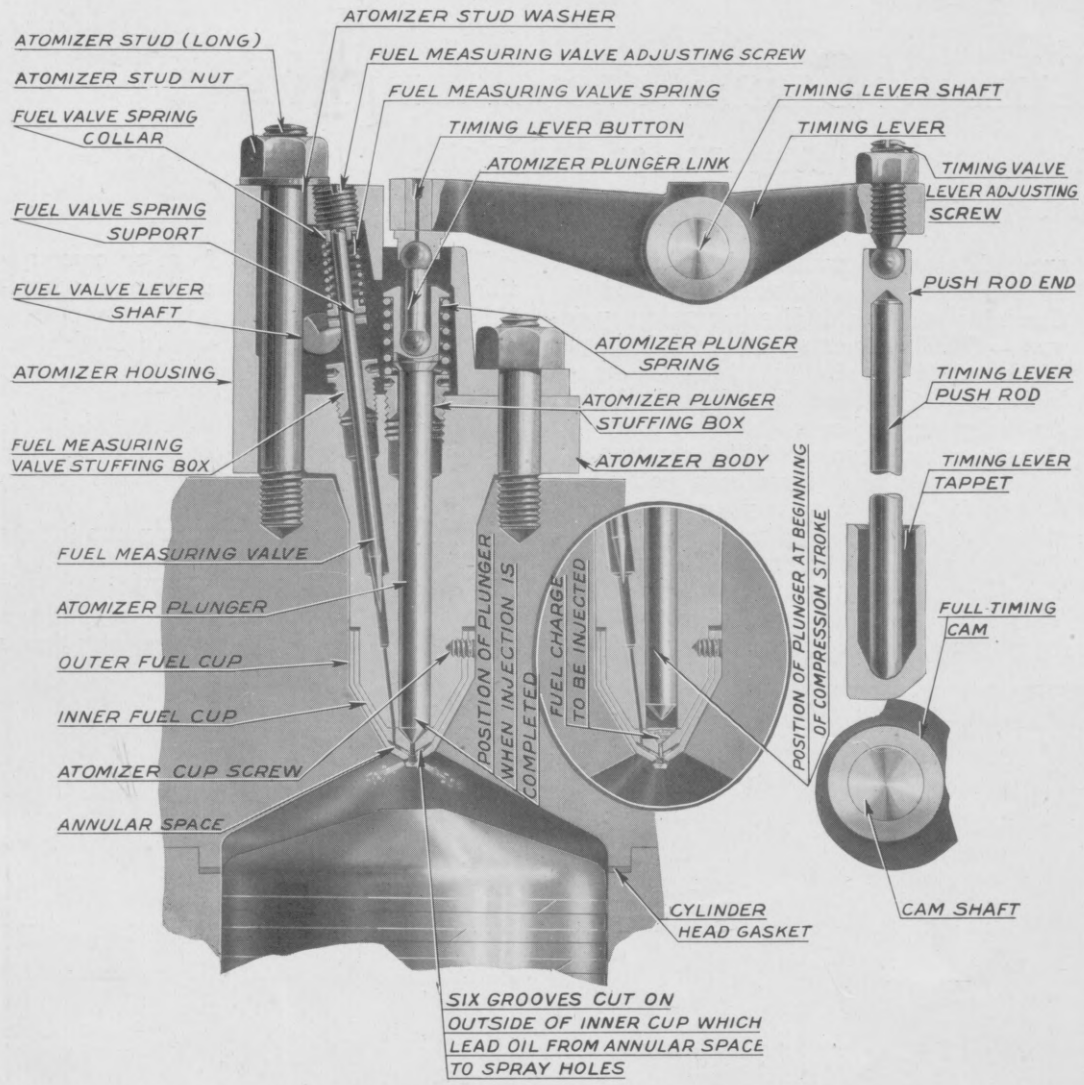


Shows diagrammatically principal features of Cummins Injection system

The body of the injector is terminated at its lower end by means of two concentric conical cups making a joint against the cylinder head casting. In the body are mounted a needle-type metering valve, A, and a forcing plunger of somewhat larger diameter, B. Both of them are mechanically operated and project outward through stuffing boxes. The needle A is elevated synchronously with the inlet valve as is the case with the Brons engine, and its motion is derived by means of the rocker E from a tappet on the air inlet lever. The plunger B, on the other hand, has its own special cam drive, the general nature of which is readily apparent from the illustration.

Referring now to the cross-section of the lower end of the injector, it will be seen that the method of operation is about as follows: During the intake stroke of the piston the needle *n* admits fuel via *m*, *k*, and *h* to the space *g* between the inner and outer cones.

During the suction stroke, also, the plunger *a* is withdrawn by the spring in conformity with the driving cam outline.

Suction in the cylinder is communicated via the fine holes *f* to the space *g* and assists the flow of fuel into it. Simultaneously the withdrawal of the plunger and the consequent enlargement of the space *c* (about ½ in. in diameter) creates a considerably stronger suction in this space. The speed of the plunger *a* as well as the numerous fluted openings through which it communicates with the space *g* allows its suction greatly to overbalance the cylinder suction communicated through *f*, so that if anything, air flows in through these holes and not out of them.

Fuel is spread out over a considerable surface of metal in entering through *h* and *g*. Vaporization helps to prepare the fuel for subsequent combustion and tends to keep the outer cup *e* at a reasonable temperature. It is especially to be noted that there is no direct communication between the inlet passage *k* and the space *c* and that the amount of metal surface covered by the entering fuel is considerable. Heating the liquid oil is the first stage in its preparation for combustion.

As there is insufficient air present in *c* to support combustion, practically all ignition within the injector is suppressed.

During the compression stroke the needle *n* is of course tightly shut while the plunger *a* has a considerable amount of space underneath it. Air now enters through the small injection holes *f* in response to the rise of compression and helps to complete the gasification of the fuel which it finds in its path.

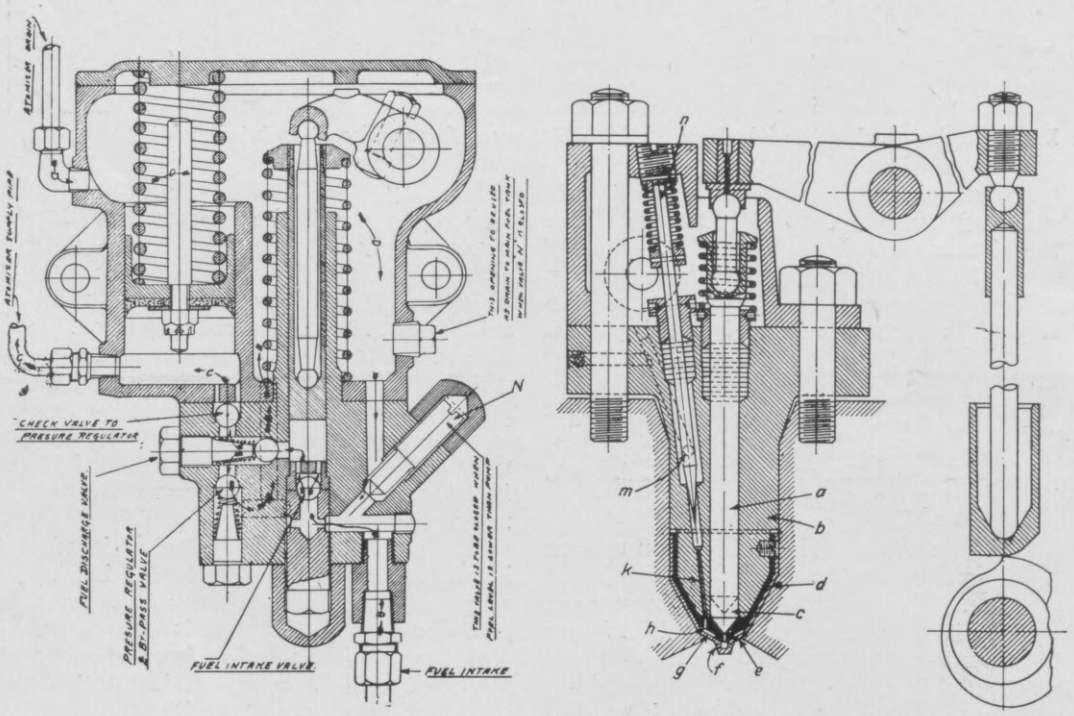
Note that the inner cone is seated against the outer one only by means of a ground conical projection of limited diameter. Six shallow flutes traverse its ground surface and establish communication between the plunger space *c* and the chamber *h*. All the six flutes converge towards the extreme tip of the pointed plunger space *c*, where they are met by the small drilled hole leading downward and into the cylinder combustion space via the fine injection orifices *f*.

Now when compressed air begins to enter through *f* during the compression stroke, it is bound to come in direct contact with the fuel previously aspirated in through the converging flutes. No matter how small the charge, it is subjected to active treatment by the entering stream of hot compressed air. It does not seem as though this effect could have been so positively achieved if the fuel had been introduced at any other point.

Passing heated compressed air through the fuel charge and thereby converting it into a gas or vapor within the plunger space *c* is designated as the second stage of fuel preparation.

Towards the end of the compression stroke a sharp, accurately-timed return thrust of the plunger *a* is said to inject a hot dry gas through the fine holes *f*. Positive mechanical timing of ignition is thus seen to be obtained in spite of the lack of an injection pump and no primary explosion is depended upon for this purpose.

During the injection movement of the plunger there is no tendency for a return



Details of Cummins fuel pumps (left) and fuel atamizer (right)

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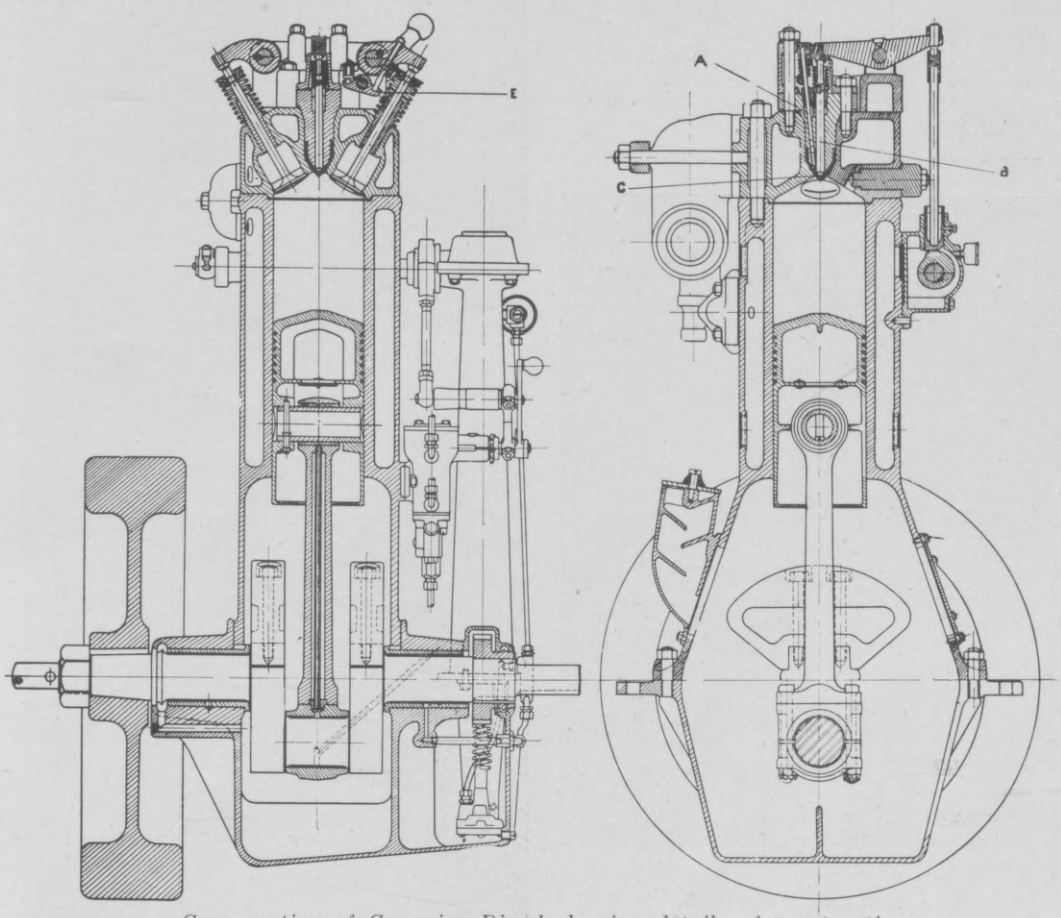
surge through the passages to *h* because they are filled solid with liquid clear back to the seat of the needle *n*. The restricted area through the grooves would further serve to prevent this. When the pointed plunger has come to its seat only a minute amount of clearance space remains, with the result that the tendency for entrapped gas to leak out when the plunger is withdrawn again is negligible.

The opening of the needle *A* (see main cross section) is varied for all cylinders by means of an eccentric fulcrum for the rocker *E*. The distribution of fuel to the individual cylinders is regulated and equalized simply by turning the knurled and spring-ratchet locked screw which holds the needle in its lifting tappet. The governor rod controlling all the eccentric fulcrums is shown in one of the photographic illustrations.

Carels Build Worthington Engine

Philip Coleman, Chairman, and O. E. Jorgensen, Diesel-Engineer of the Worthington Pump & Machinery Corp., recently returned from Europe, having concluded arrangements whereby a license to manufacture the new Worthington double-acting Diesel engine for marine and stationary purposes was acquired by Carel-Freres of Ghent, a subsidiary of the International General Electric Co.



Cross-section of Cummins Diesel showing details of construction

Nickel Alloy Pistons Improve Performance

Engine Power Can Be Increased, Wear on Bearings Is Reduced, Acceleration Improved and Smoother Running Obtained

UNTIL Bu-Nite nickel alloy pistons were introduced, the demand by designers of medium speed and high speed Diesel engines for pistons lighter than cast iron and transmitting the unused heat energy faster to the cylinder walls remained unsatisfied. Experiments with pistons of straight aluminum and of aluminum alloys have been chronicled in the past, but these efforts merely demonstrated there was no direct road to the solution of the problem. That Bu-Nite nickel alloy pistons seem to fill the bill appears plainly from the extensive use now being made of them in Winton, Bessemer and other engines of the faster running types.

Use of such pistons is of direct interest to the vessel owner. They contribute to superior performance of the engine. Power can be increased without overloading, wear on the bearings is reduced and a decreased consumption of fuel and lubricant are often registered. There is also an improvement in factors not easily measured in dollars and cents, such as smoother running, faster acceleration, etc.

Bu-Nite pistons weigh on the average less than one-half of the cast iron pistons they replace. This considerable reduction of weight means a big cut in the reciprocating masses. The effect on the engine performance is exemplified by the statement of the chief engineer of Carl Fisher's fast Diesel-engined yacht SHADOW K which has two 500 hp. Winton engines, with 14 in. pistons and turning up at 425 r.p.m., run unusually smoothly and quietly with the Bu-Nite pistons, exhibiting considerable superiority over the cast iron pistons with which the engines were tested. With an engine speed of 425 r.p.m. the pistons make 850 strokes per min., and the benefit of a big weight reduction in the reciprocating masses is obvious as soon as one notes these figures. The same engineer reports that he can lift the Bu-Nite piston unaided, whereas the 14 in. cast-iron piston for that size of engine is almost too much for two men.

Eventually, the lighter type of piston will be adopted for all Diesel engines, because there is no reason for the use of the heavy cast-iron piston other than that it has heretofore been the only one that stood up to the service. At the present stage of development the Bu-Nite type has been made and given good service in diameters up to 16½ in. It has so far been adopted only in engines of the higher speed classes, not because it is suitable only for them, but because its advantages quickly appealed to the builders of that type.

With greater knowledge of the Diesel engine art, a number of manufacturers have during the past few years turned their attention to higher engine speeds and made a success of it. Most of the large Diesel yachts favor this type of machinery, which is also coming into vogue for Diesel-electric installations. One of the details that has to be watched more closely in these engines than in slow speed sets is the transfer of the unused heat energy from the pistons to the cylinder walls through which it reaches the cooling water. Due to its superior heat transmitting properties the Bu-Nite piston does not reach the "heat saturation" point nearly is quickly as the cast-iron type and therefore permits the high engine speeds to be endured with safety. That is a very important advantage. Another aspect of the same problem is that an engine could be run with plain Bu-Nite pistons when oil-cooled pistons or water-cooled pistons would need to be used if cast-iron were employed. All the Diesel yachts built last year with engines of 500 hp. and 800 hp. are using Bu-Nite pistons.

For compressor pistons the use of the Bu-Nite principle has advantages equally marked. Particularly in regard to the balance of the reciprocating parts of the compressor does this new type of piston offer considerable benefits. Compressors are mostly of the single-crank type and apt to give rise to vibration at high engine speeds. Cutting down the weight of a long 3-stage piston makes a great improvement.

Bu-Nite pistons are made by the Butler Mfg. Co. of Indianapolis from an alloy of nickel, aluminum and copper produced by a special process which results in complete union of the metals. The nickel content gives unusual qualities of strength and toughness in marked superiority over ordinary aluminum alloys that lack these properties. All the mixes are made of virgin 99 per cent aluminum ingots alloyed with nickel and copper. No scrap metal whatever is used, and even the shavings turned off in rough machinery the pistons before shipment to the engine manufacturers are sold for junk.

The melting point of Bu-Nite nickel metal is between 1250 deg. and 1300 deg. Fahr. However, the important consideration in a piston metal is not its melting point, but the degree of strength it retains at the highest temperatures reached in an engine cylinder, about 700 deg. The metal has been developed to give exceptional strength and stamina at that temperature and is capable of withstanding unusual punishment and long, hard service under the hottest and most gruelling motor operation. It transmits all heat 3 and 3½ times as rapidly as cast iron, thus avoiding undue heating in the piston head and passing the heat on quickly to the water of the cooling

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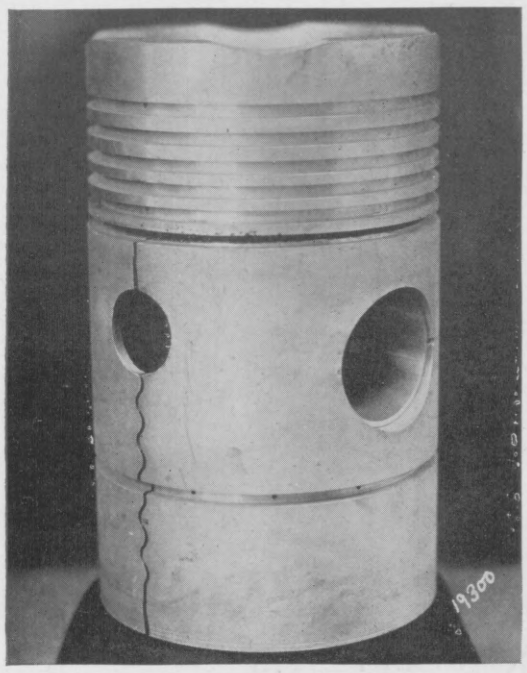
system. Detonation and pre-ignition due to overheating are thus done away with. Carbon deposits do not form on the under side of the piston heads, because that surface in normal operation never grows hot enough to burn the lubricating oil splashed on it.

This piston alloy is very tough and resilient,

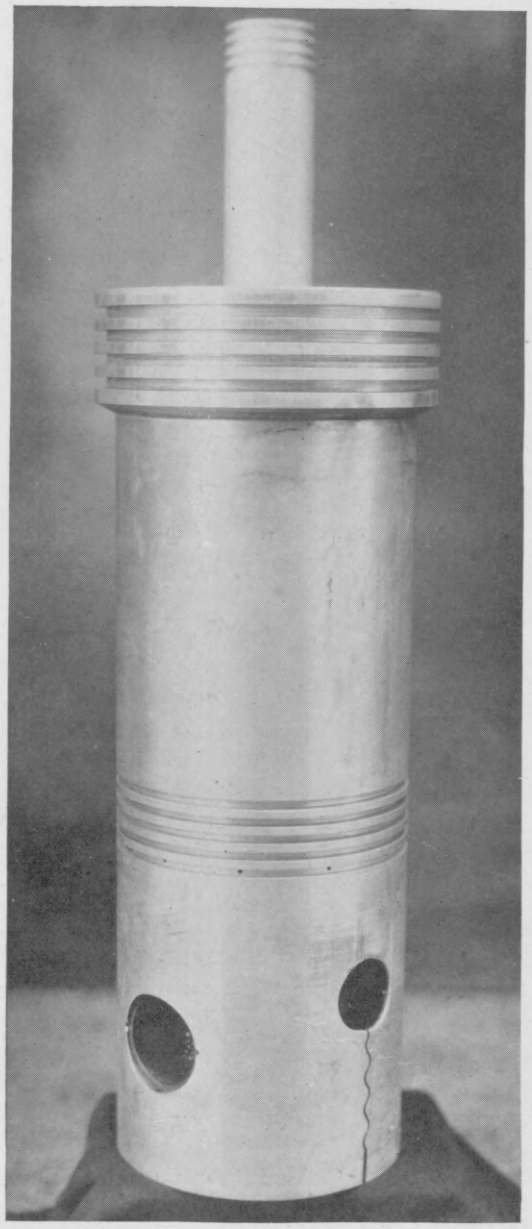


Typical Bu-Nite piston

in contrast to the brittleness of ordinary lightweight piston materials used in automobile engines. A Bu-Nite steel-band piston can be struck heavy blows with a sledge hammer, or can be compressed in a vice until the sides of the skirt come together, without breaking up into pieces as ordinary alloy and cast iron pistons do under such abuse.

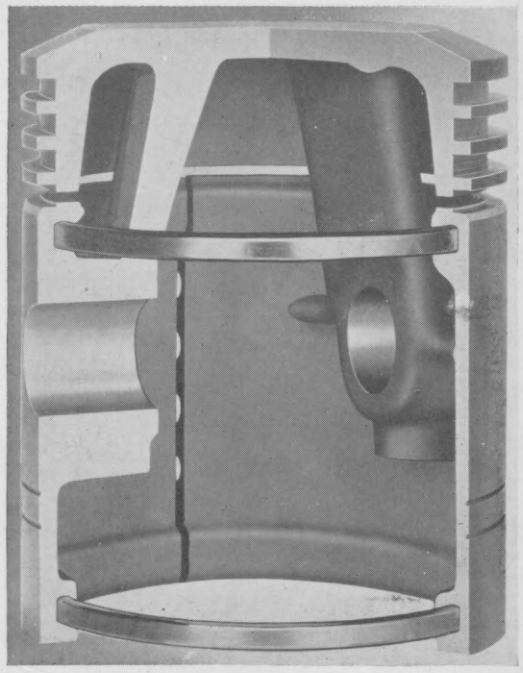
Bands of steel amply large in section to give an excess of strength for the desired purpose, are cast in the metal of the skirt, one above the piston pin and one near the bottom edge, with additional bands in other locations if required by design.

Aluminum and steel will not weld at the melting temperature of the alloy and the steel bands thus remain free from alloy though closely surrounded by it. The steel bands act as tracks to guide the motion of the metal around the circumference and close the wave slots partially as the pistons are heated. The



Bu-Nite compressor piston

only expansion in the direction of the diameter is that permitted by the expansion of the steel bands themselves, which is slightly less than the rate of expansion of the cylinder liner. Instead of becoming tighter as the motor grows hot, as ordinary types of pistons do, Bu-Nite pistons actually give more clearance which is desirable because a heavier film of lubricating oil is needed to withstand high temperatures than when the motor is cool, and this variation of film thickness is provided for by Bu-Nite control of expansion which gives more clearance at higher heats.



Sectional view of piston

Maximum results cannot be derived merely by installing lightweight alloy pistons in an engine designed for iron pistons. To obtain the utmost in performance the entire motor design should be worked out on the basis of light reciprocating parts, high mean effective pressures and rapid conductivity of heat.

Atlantic Refining Co. has ordered Ingersoll-Rand type engine and electric equipment for a Diesel-electric tanker from the Procédé Thomsen-Houston & Carels, Ghent, Belgium. Hull will be built by Scott Sb. Co., Greenock, Scotland.

Chas. Ward Engineering Co., Charleston, West Va., has been awarded contract for a stern-wheel river survey boat by the Mississippi River Commission. The vessel will have an overall length of 139 ft. 6 in. and will be propelled by a 240 hp. Bethlehem engine.

Review of Recent Publications

Zusammenfassende Darstellung Von Schraubenversuchen

By Dr. Ing. W. Schmidt. 13½ *in. x* 8¼ *in. x* ⅛ *in.;* 16 *pp. Price* 4 *marks. Published by V. D. I. Verlag, G. m. b. H., Berlin, N. W.* 7.

Advent of the motorship, with its generally higher propeller revolutions than the reciprocating-engined steamer, has caused greater technical attention to be devoted to the problem of propeller design which is also changing. When only steamers were built, model experiment data played a very small part in helping an engineer to decide the requisite design of wheel, since his task then was merely that of an interpolation of his previous successful experience. To those firms just going over to Diesel drive, wheel design is something of an extrapolation of experience; and hence every assistance must be sought to make this extrapolation as safe as possible. One such assistance is the exhaustive data available on the performance of model propellers.

Dr. Schmidt, the author, who for some time was at the Berlin Tank, has succeeded in compressing into seven clear diagrams the information contained in 105 diagrams previously published by Dr. Schaffran. Schaffran's work embraced the performance characteristics of a family of model propellers having respectively 2, 3 and 4 blades, of pitch ratio varying from 0.6 to 1.5, and of surface ratio varying (in the four-bladed screws) from 19 per cent to 75 per cent. The mine of information contained in the work can be appreciated.

In amplification of his diagrams, Dr. Schmidt illustrates their application to the usual problems arising in practice and incidentally has some valuable observations on the question of cavitation. Although the book is of course written in German, the diagrams (round which the book is written) really require no great knowledge of that language for their adequate comprehension. We can therefore confidently recommend this new publication to all interested in questions of propeller design.

The Directory of Shipowners, Shipbuilders, and Marine Engineers, 1927—*25th edition.*

Compiled under the direction of the Editor of Shipbuilding and Shipping Record. 8½ *in. x* 5¼ *in. x* 1¼ *in. Price* 20*s. net. Published by the Directory Publishing Co. Ltd., Westminster, London, S. W.* 1.

Here is one of the most useful deck companions on the market, furnishing particulars of the leading steamship companies, shipbuilders, ship-repairers, and marine engineering works throughout the world. It gives the names of the directors and principal officials and details of the fleets owned by the shipping companies. A supplementary section includes a list of societies, institutions, trade and labor federations, and a directory of consulting marine engineers and naval architects.

The details have all been most carefully compiled and are reliable since they are based on returns from the actual owners. The book is international in its scope.

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